Faculty of Science and Technology

BSc (Hons) Games Technology

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3D GAME ENVIRONMENT BASED ON HALO DESIGN WITH ASSET CREATION

by

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Abstract

Since the early 2000's, modern video games have shifted their attention from Single Player to Multiplayer paradigm. Halo has achieved great success with its multiplayer gameplay for over a decade, especially in terms of it multiplayer Level Design. This project will understand and implement a Halo-inspired multiplayer map using modern games development techniques such as PBR as well as a suitable Level Design pipeline.

The level created, Pegasi Delta, will be based on a scene described in the Halo novel 'Ghosts of Onyx' and was chosen by the Halo community as this scene has never been depicted as a games environment before. This project used Maya for 3D modelling, Substance Painter for texturing, Simplygon for LOD creation and Unreal Engine 4 (UE4) as the game engine. The project was evaluated by comparing professional practice to what has been undertaken during the development of the project as well as the inclusion of a questionnaire aimed at Games Development students and Halo enthusiasts. Results show that the project was successful, however, more work is required to make Pegasi Delta industry standard, and gameplay testing needed to confirm that Game Design theories applied to the project were successful.

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1 Introduction

1.1 The project

With the uprising of the Multiplayer First person shooter (FPS) genre, the franchise of Halo, consistently has some of the best and most renowned Level Design in modern video games, particularly under the original developer, Bungie.

Founded in 1991 by Alex Seropian, Bungie is a highly successful AAA games studio most famous for the game series Halo. In 1997, Bungie began development of Halo Combat Evolved (CE), initially a Real Time Strategy, then a Third Person Shooter game. Meanwhile, Microsoft were about to break into the games market with the original Xbox. Consequently, Microsoft acquired Bungie to make Halo exclusively for the Xbox and evolve it to an FPS.

Halo CE released in 2001 selling more than 6.5 million copies. The game revolutionised the FPS genre and set the highest standard for multiplayer game play with its up to 16 player combat, host of high quality maps and plethora of game modes. Bungie would have further success with Halo with 4 more games being developed. After Bungies and Microsoft's split in 2010, the Halo franchise continued its success under new developer 343 Industries.

1.2 Aims

Multiplayer FPS's have some of the most renown Level Design in gaming. None more so than the Halo series. Despite the development of multiple Halo games spanning over many years, Bungie, has been able to consistently create high quality and popular multiplayer maps. Considering this, the aim of the project is to enable the learning and application of professional practice for the level creation pipeline, resulting in the development of an original Halo inspired map of equivalent or better.

1.3 Objectives

The following objective must be fulfilled:

1. Revise, research and apply an appropriate level creation pipeline such as Continuous Iteration
2. Investigate Bungie's multiplayer Level Design and apply this knowledge
3. Investigate theories and techniques for the planning and pre-production of a level such as concept art
4. Research and apply new asset development techniques such as PBR and Photogrammetry where appropriate
5. Identify and apply techniques creating high quality lighting in games
6. Demonstrate successful creation and improvement of skills with a high-quality game level

2 Background of professional practice

In the games industry, multiple professions will be in some way involved in the level creation process. According to Stephane Boudon (Boudon, S., 2016) a lead Level Designer at Ubisoft Paris, a Level Designer will work with "Programmers, Animators, Game Designers and Graphic artists".

This section will explore some of the tools and practices available to the various disciplines that collaborate in tangent with Level Designers as well as exploring the state of Level Design.

2.1 Multiplayer Level Design

2.1.1 Current industry practice

Level Design in the first-person shooter genre has transitioned greatly over the last 20 years from the then popular symmetrical battlegrounds of Unreal Tournament and Quake, to the vast horizontal, asymmetrical and destructible environments portrayed by game series such as Battlefield. This change has coincided with the shift in focus from single player to multiplayer.

Radical changes in the requirements of Level Design have emerged. As described by Elisabeth Schwartz (Schwartz, E., 2017), moving from the role as a single to a multiplayer Level Designer is "a paradigm shift".

Schwartz described the main considerations when designing a multiplayer versus a single player level. One of these considerations was level size. In a single player level, a designer must consider the number of combat points and the size of those that occur in a level. It is also important to identify any narrative set pieces that will be occurring in the level as single player levels are designed primarily to drive a games narrative.

On the other hand, when designing a multiplayer level in terms of size, more common points of consideration are the number of players that a level should support and the intended time until players would typically engage one another. This shouldn't be so long as to bore the player but shouldn't be as short as to make the player feel boxed in.

Framing and Composition is an important consideration in Level Design for both multiplayer and single player. As aforementioned, single player focuses on storytelling and gameplay objectives. As explained by Steve Lee (Lee, S., 2017) it is important in single player mode for the player to always know their objectives and location so as to not get lost.

While gameplay objectives are important to multiplayer levels, the focus is shifted to player paths and making sure the maps layout doesn't allow for exploits. Player paths refer to the options and choices a map provides for navigating the environment. It is important to not oversaturate the player with paths so that the number of player engagement isn't reduced that the player will be bored. It is just as important to provide enough routes, so the player won't feel trapped or become being boxed in due to the opposing team's dominance. By adding multiple routes, you provide a level of unpredictability as a player may not know from which direction an opposing player might come. It provides the player more strategic options, meaning no one strategy should decide a game. It's also important for these paths to be clear so that split-second decisions on how to traverse the map can be made.

Identifying and fixing exploits are key, as unfixed exploits can lead to players gaining an unfair advantage which can results in opposing players not enjoying the game. Schwartz (Schwartz, E., 2017) described how a pillar and top of a stairwell allowed a player to shoot other players whilst remaining hidden from sight (figure 1). This caused players to get frustrated and feel like they were being cheated by the game through no fault of their own. If an exploit like this remains unfixed, it can have consequences to player retention.

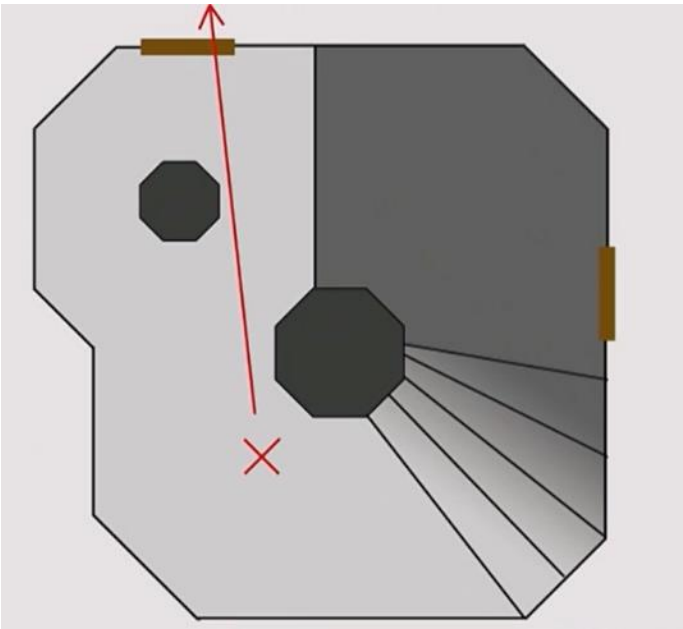

Figure 1 - Example of a multiplayer exploit as described by Elisabeth Schwartz (Schwartz, E., 2017)

Finally, play-testing is critical in the development of levels. As single player levels are typically played once per user, these levels should be nearly completed before play testing so that the experience will emulate what the end user will encounter. It is therefore important to use a variety of testers, as not to do so wouldn't be an accurate reflection of how a level will be played by a user. On the other hand, a

multiplayer level should be tested by many people early on in development and the design should be iterated upon throughout development.

For multiplayer levels, the layout is far more important than an aesthetically polished level as players first impressions aren't a major concern of multiplayer maps. However, it is good practice if the level can direct the player to combat, even if the player is unfamiliar with the map. This means a player with limited experience can still have fun on the level. When a player repeatedly plays on a map, they will learn the layout and develop tactics with experience.

2.1.2 Bungie's Halo practice

Throughout developing Halo, Bungie has been able to create multiplayer maps to near perfection using the considerations discussed above. In each game, standards for multiplayer maps were constantly high with many critics praising Halo's multiplayer map design, including games designer Scott Rogers. It was clear that Bungie focused on making the best possible multiplayer experience though Level Design.

Hardy LeBel (LeBel, H., 2016a) worked on multiplayer maps for Halo CE (2001) and Halo 2 (2004). He explained that game levels are important for a variety of reasons. Firstly, levels present game spaces which incorporate gameplay for a player. They also provide a playground for the game's mechanics to be used and interacted with. Finally, levels also define spatial constraints for the player (i.e. zones where they can or cannot go), as well as gameplay constraints.

During the development of Halo CE and Halo 2, LeBel (Lebel, H., 2015 b) stated that when it came to levels, "Function needs to drive form". This meant that the developer (Bungie) believed that a level needed to, primarily, complement game mechanics and level art would be designed to suit this.

When asked about modern map design, Lebel talks about the industries move away from verticality in maps. He claims that "People hate to look up and down in a first-person shooter". He goes on to state that this theory "is supported by level artists" as "levels are designed to look beautiful horizontally, but not vertically "(Lebel, H., 2015 b). This is clearly demonstrated when looking at a Halo CE level such as 'Hang 'em high' (Figure 2) vs a Halo 3 level, 'Standoff' (Figure 3).

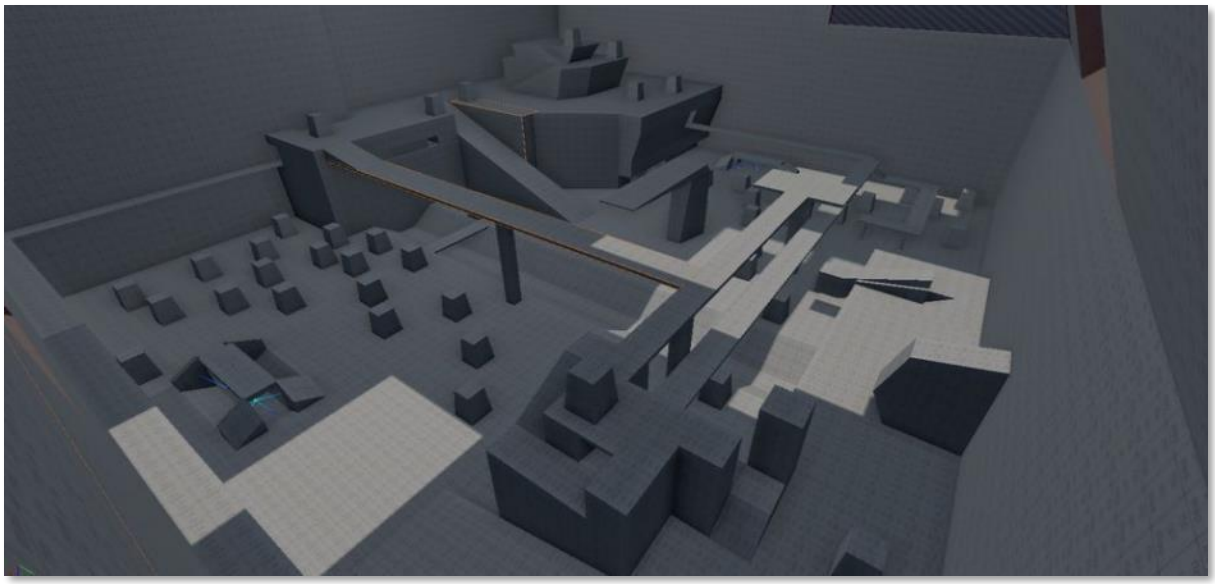

Figure 2 - Hang 'em High from Halo CE (Aeharding, 2010)

Figure 3 - Standoff from Halo 3 (Spartan-112a, 2010)

In terms of Halo's Multiplayer design, it is also important to consider the game types that a map supports. Halo multiplayer maps support a large range of game modes which makes each time a map is encountered a unique experience. In addition, Halo maps would typically consider vehicular support when being designed. Halo has a range of vehicles differing in function and play styles. Therefore, these will need to be accommodated for in the design process. Halo always presents players with multiple routes to reach a target or area of the map. Research conducted by this paper, found that Halo's larger maps typically feature 3 routes (see LDD in appendices A).

While most of Halo's level development process has been kept behind closed doors, some information discussing the process has been unearthed by James Monroe (Monroe, J., 2014), an Environment Artist at 343 Industries.

Monroe states that typically he receives a "rough layout" from Level Designers made up of basic primitives. The environment artists job is to then bring "visual meaning" to these primitive shapes. From a video documentary on the development of Halo, it's known that Bungie would gameplay test these block-outs, to be sure that levels would be fun to play before handing the map over to environment artists.

Monroe stated that environment artists would be in constant communication with Level Designers throughout a project in addition to other design roles on the team. If any changes are made to a maps structure, they are usually cleared with the Level Designer first so that the map stays true to a Level Designers vision and won't disrupt the intended play style.

2.1.3 Methodologies

A Level Designer's role can differ significantly between different studios in terms of who they work with and other areas of development they may work on. However, most studios and Level Designers follow a relatively similar base structure. As described by Alex Galuzin (Galuzin, A., 2016), these structures are typically made up of four main categories in development.

1. **Planning and Preproduction:** a plan, vision of an idea to go after that is concrete and worthwhile to pursue.
2. **Gameplay:** includes pacing, flow, balance, objectives, obstacles, set pieces/scripting and player progression/experience.
3. **Visuals/Artistic:** colour, lighting, style, textures, materials, aesthetics; the visuals of the environment (graphics).
4. **Technical:** knowledge of the software and technical game art foundation – 3D modelling, UV mapping, texturing, level editor tools.

Typically, all planning and preproduction will be undertaken first. It is important to define both gameplay and artistic elements of a given level. In industry, it is common for both Gameplay and Visual categories to be undertaken by multiple disciplines. For example, a Level Designer will work closely with a games designer when designing a map layout, while a Level Designer may not work on texturing or lighting etc. This role may be fulfilled by an Environment artist. However, this depends on the Level Designer role being either "Dallas", where many of the roles are performed by a Level Designer, or "California" where the Level Designer focuses their attention typically on level layout and some scripting. Dallas style is being phased out by larger companies as they split the role of Level Designer into other more specialised roles such as Environment Artist or Technical Artist, whilst still retaining the role of Level Designer (Flanagan, J., 2011).

It is important to be constantly iterating upon a multiplayer level. However, creating a game level can be a long process which can result in boredom. Techniques have been developed to keep designers motivated and engaged in the Level Design process. One such technique used by Games Studio Bethesda, is Spaced Iteration (figure 5). Unlike Continuous Iteration (figure 4), it involves developers working on the same iteration of multiple levels at a given time, before moving onto the next iteration. Bethesda's Joel Burges (Burges, J., 2014) states that Spaced Iteration keeps work fresh - preventing boredom and working in a more structured and incremental fashion, which allows time for more thorough testing and feedback.

While Burges doesn't talk about any downsides to continuous iteration, from the authors viewpoint, there are a few limitations with the methodology. It may be possible when having large breaks between

a single levels iteration, that momentum in developing a level could be lost. It is also possible to foresee a scenario where an iteration of a level may hold up the development of other levels. While studios like Bethesda focus on single player levels, this could be a much larger issue on multiplayer levels which require more iteration and testing. Single player levels can be broken into a rigid 4 iteration process (Concept, Layout, Mark-up & Polish). Multiplayer levels can require many more iterations which cannot be planned. For example, a multiplayer level may go though many concept and layout iterations, whilst another level may only need one based on testing. This makes it difficult for a set timeline to be implemented using spaced iteration.

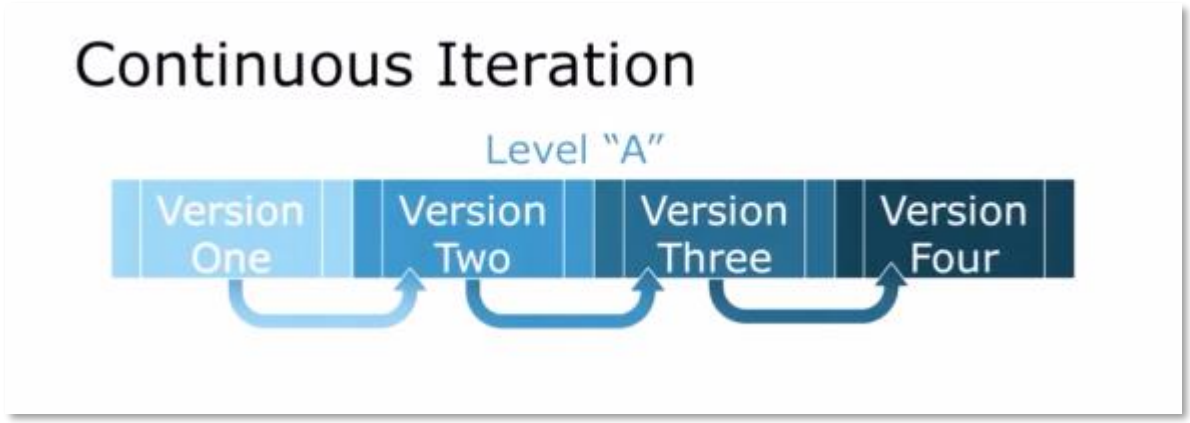

Figure 4 – Continuous Iteration (Burges, J., 2014)

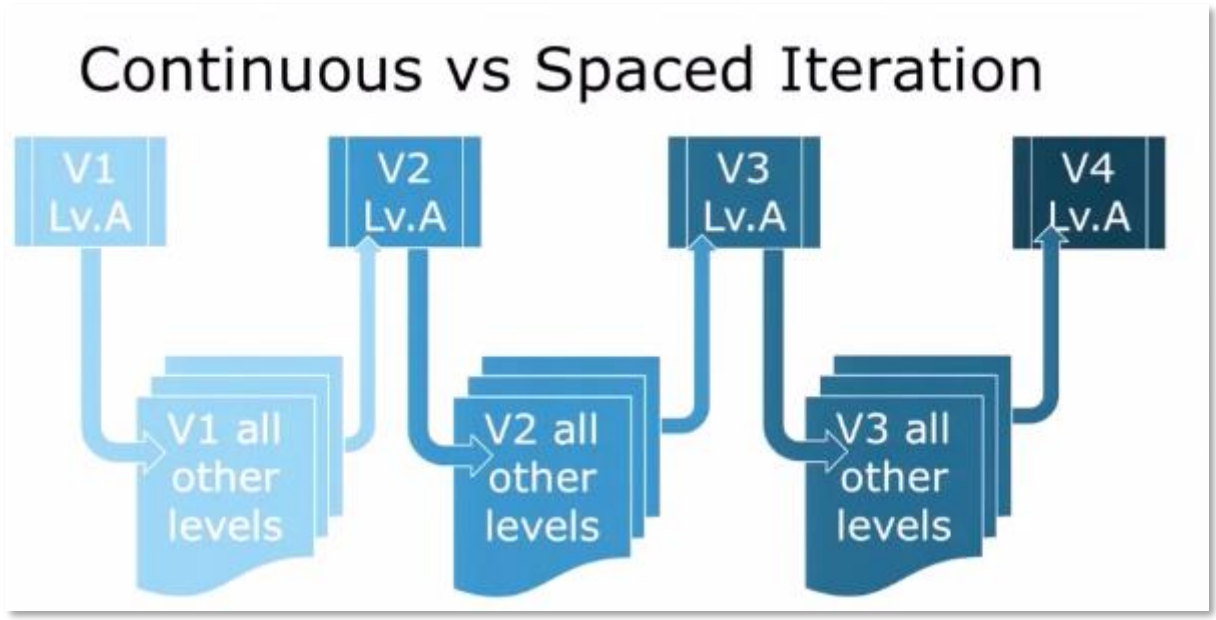

Figure 5 - Bethesda's Spaced Iteration (Burges, J., 2014)

2.2 3D modelling

2.2.1 Current industry practice

3D modelling techniques have recently transitioned from the traditional methods of Polygonal modelling to modern techniques such as Photogrammetry. Polygonal Modelling is a "technique in which the artist starts with a geometric primitive (cube, sphere, cylinder, etc.) and then refines its shape until the desired appearance is achieved." (Slick, J., 2017)

Photogrammetry is the process of digitising real-world objects. As explained by Justin Slick (Slick, J., 2017), this is achieved by scanning a real-world object and harvesting the raw data (typically X, Y, Z coordinate cloud) to generate an accurate polygonal or NURBS mesh. This can be used for modelling from characters, vehicles, trees and landscapes. However, there are downsides to this method. Bjorn Arvidsson (Arvidsson, B., 2015), a character artist of the Star War Battlefront game, explained that using this method for Darth Vader was a challenge. He went on to say

> *"The photogrammetry software searches for common points where it can match the images taken and if it's only black and shiny, you won't get anything from it."*
> *(Arvidsson, B., 2015)*

Similar issues were highlighted when trying to capture wet landscapes. An example of a Photograme terised scene can be seen in Figure 6.

Figure 6 – Photograme terised scene & assets from EA's Star Wars Battlefront (Arvidsson, B., 2015)

In addition to Photogrammetry, digital sculpting with applications such as zBrush, have become an industry standard. This program offers a selection of ground-breaking tools for developers to create static meshes.

Another important new modelling technique is procedural modelling. While in it's infancy within the games industry, procedural modelling has existed in the world of film and television for some time. With its introduction, it allows for the creation of many similar, yet differing meshes. This is especially useful when creating modular game assets. Instead of making many similar assets, a developer can create a single asset and use modifiers to transform a mesh into a procedural mesh. An example can be seen below for a modular pipe in UE4 (figure 7 & 8).

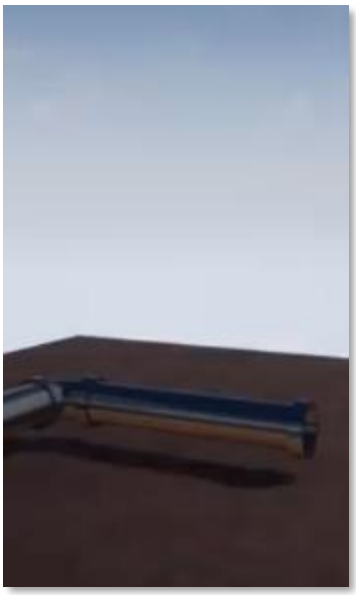

Figure 7 - Procedural pipe before extrusion

Figure 8 - Procedural pipe after extrusion

2.3 Texturing

2.3.1 Current industry practice

Physically Based Rendering (PBR) texturing allows for textures to be rendered in a more photorealistic manor when compared to older techniques. As described by Nick Pettit (Pettit, N., 2015), "PBR delivers more consistent and predictable results". Another benefit of PBR is" the ability to create realistic results quickly", (Pettit, N., 2015). An example of PBR shaded content can be seen in Figure 9.

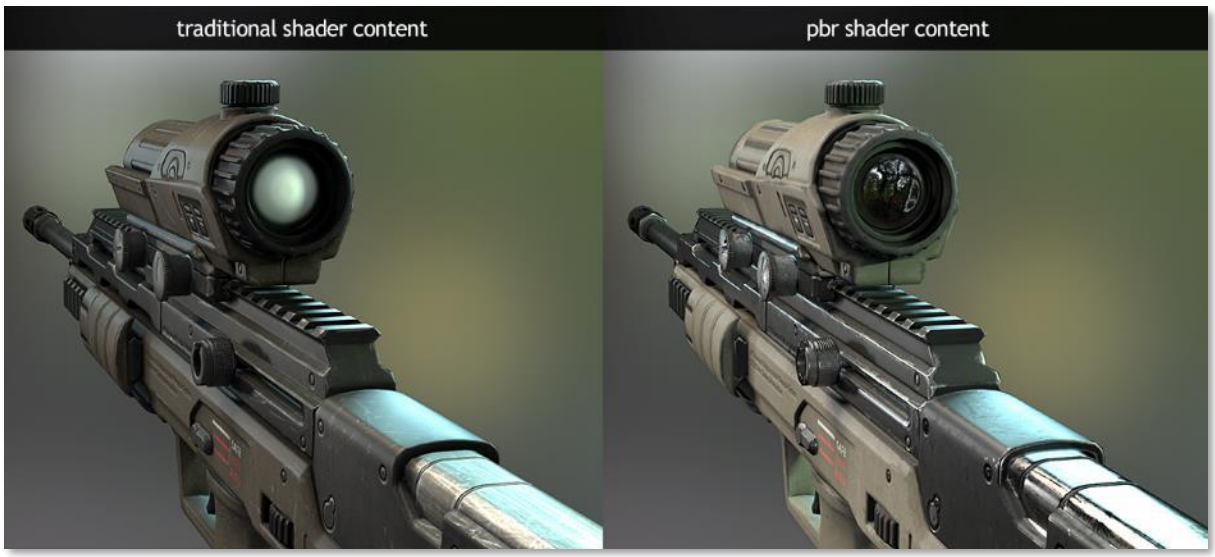

Figure 9 – Traditional Texturing vs PBR workflow (Wilson, J., 2015)

Quixel and Substance Painter applications have become industry standard for PBR. Quixel requires Adobe Photoshop to texture a model while Substance painter is a standalone program. In addition, Substance Painter has a powerful set of smart generators that can be used to easily and accurately apply effects such as dirt on a mesh by mathematically calculating where dirt would be found on a mesh (for example, in small gaps or holes etc…). PBR is supported by most mainstream engines, including Unreal Engine 4 and Unity.

2.4 Game Engine analysis

There is a wide variety of game engines each with its own unique features. The most popular of which, as of 2016 is Unity3D which has 45% of the Games Engine market (Kolambe, H., 2016a). Unity's popularity is because of its "low learning curve" (Kolambe, H., 2016b) and its cross-platform integration, (Kolambe, H., 2016b). Its closest competitor, Unreal Engine 4 (UE4) has its own unique technologies. One of these technologies is Blueprints (Figure 10); a visual scripting system which allows for a game to be created without the need for traditional coding. Anton Bevza (Bevza, A., 2015) claims that Blueprints allow for the development of "fast prototypes" to be created. UE4 also allows for a greater graphical fidelity. This is achieved through "complex particle simulations systems to advanced dynamic lighting (Malhotra, M., 2017).

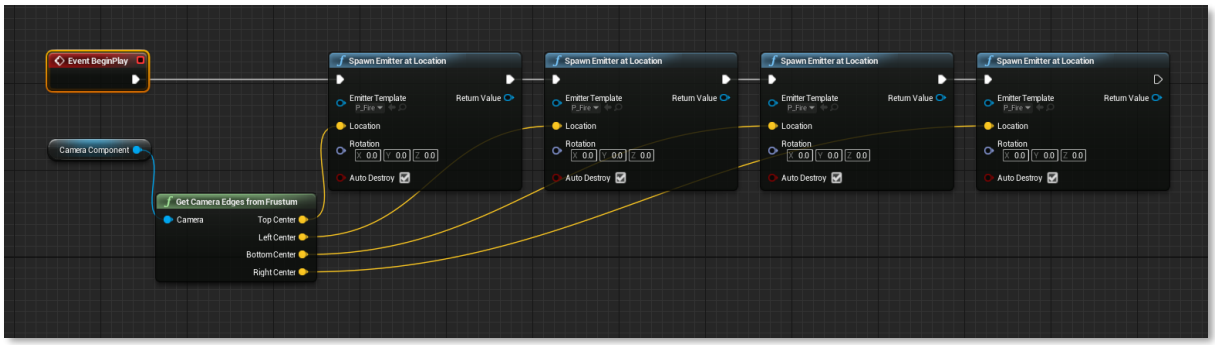

Figure 10 - Example Blueprint from UE4

2.5 Applicability of researched techniques to project

Whilst the author aimed to apply industry standard throughout the project, many of the above techniques were unsuitable.

The techniques described above discussing multiplayer Level Design vs single player design have been considered. The author acted as a Dallas styled Level Designer as multiple roles need to be fulfilled. In addition, continuous iteration was used instead of spaced iteration as only one level was being developed.

Conventional modelling techniques were used instead of sculpting and procedural. This was chosen as 3D modelling was not the focus of this project and in addition time was needed to learn these techniques. Photogrammetry is not suitable as neither landscape nor props were accessible to be photo-scanned,

To build the level, the author used PBR texturing for all created assets as well as the UE4 engine.

3 Methodology

This section will focus on processes involved in development of a Halo (Bungie era of development) inspired multiplayer level. Primarily, this section looked at 'Planning and pre-production', the 'Development of art asset's, the 'Implementation of art assets' and 'Final touches' for the level.

3.1 Planning & Pre-production

3.1.1 Initial research and Level Specification

To support the development of this project the author initially undertook secondary research in:

- Multiplayer Level Design
- 3D modelling techniques
- Texturing
- Modern Game Engines

Much of this research was discussed during the Background of Professional Practices section of this dissertation (chapter 2).

Additional topics such as Project Management techniques were also researched including AGILE methodology. However, this section has been removed as AGILE would have been better suited for a project with multiple personnel involved in the development process.

A Level Designer may have some creative control in terms of problem solving and flow of a level. However, a Level Designer will have a set of criteria which a level should meet. This would typically be decided in a 'Level Design Document' (LDD). This would help ensure a Level Designer would create what's needed whilst still allowing for some creativity.

During the project proposal stage, it was agreed that the level created had to be large in scale. Therefore, it was important to analyse Bungie's large multiplayer map design for Halo to understand the flow and style of their maps (see appendices A for LDD).

A story/theme needed to be allocated for the level. To closer mimic industry, a third party was used to choose a theme from Halo. This was proposed to several Halo community forums, so that the fans of the game could choose this key aspect.

The theme of 'Pegasi Delta' from the Halo novel 'Ghosts of Onyx' was the most popular choice and provided an interesting challenge due to the lack of information about this theme.

"Pegasi Delta is a small world in the 51 Pegasi system, and a natural satellite of the planet 51 Pegasi B. The surface of the world was made of red rocks and sand. Orange dust permeated the sky and had a faint yellow sun, 85 Pegasi-194A. It had seas that were unusually green and rich in Deuterium and Tritium, which the Covenant used in their plasma reactors, and it was used to refuel their ships." - Eric Nyland (Nyland. E., 2005).

Full information regarding any description of Pegasi Delta along with Game modes, Vehicles & Target

3.1.2 Project management

To maximise efficiency and to meet deadlines, it was important to utilise suitable project management methodologies.

For the development of Pegasi Delta, the author investigated the aforementioned AGILE methodology for development. AGILE would be suitable for the development of a whole game where the overall pipeline may be more flexible. Applying this methodology for a single level is less suitable, as the pipeline is more rigid, and many steps need to happen in sequence.

Instead, a Gantt chart was created using Microsoft Project. This chart had a breakdown of all the major categories of the Level Design pipeline using information discussed in chapter 2.

- Planning & Preproduction
- Creation of Art Assets
- Implementation of Art Assets
- Final Touches (Polish)

Each tasks duration was estimated using both research and the authors experience with games development.

Full Gantt chart can be found in appendices D.

Figure 11 – Pegasi Delta Gantt chart

3.1.3 Concept art

Concept art is used to visualise various art, conveying a visual representation of a design idea (Pickthall, J., 2012). This ensures work produced between varying disciplines is consistent. This is particularly important for aesthetics. If two designers create two different assets designed to be in the same location, yet their aesthetics are substantially different, players may notice the inconsistency and potentially lose immersion.

Due to a lack of 2D art skills, an attempt to use a third-party artist was undertaken. However, this never materialised so the author had to create the art.

Various techniques were attempted including using a collage of edited images to create a scene as well as a more traditional approach to concept art. However, these images were difficult to understand and generally didn't represent the concepts the author wanted to present. A technical style was used representing top and side views. These drawing were completed for the map layout (Figure 12) and main player bases which would be unique in their design. B1 and B2 represent player bases.

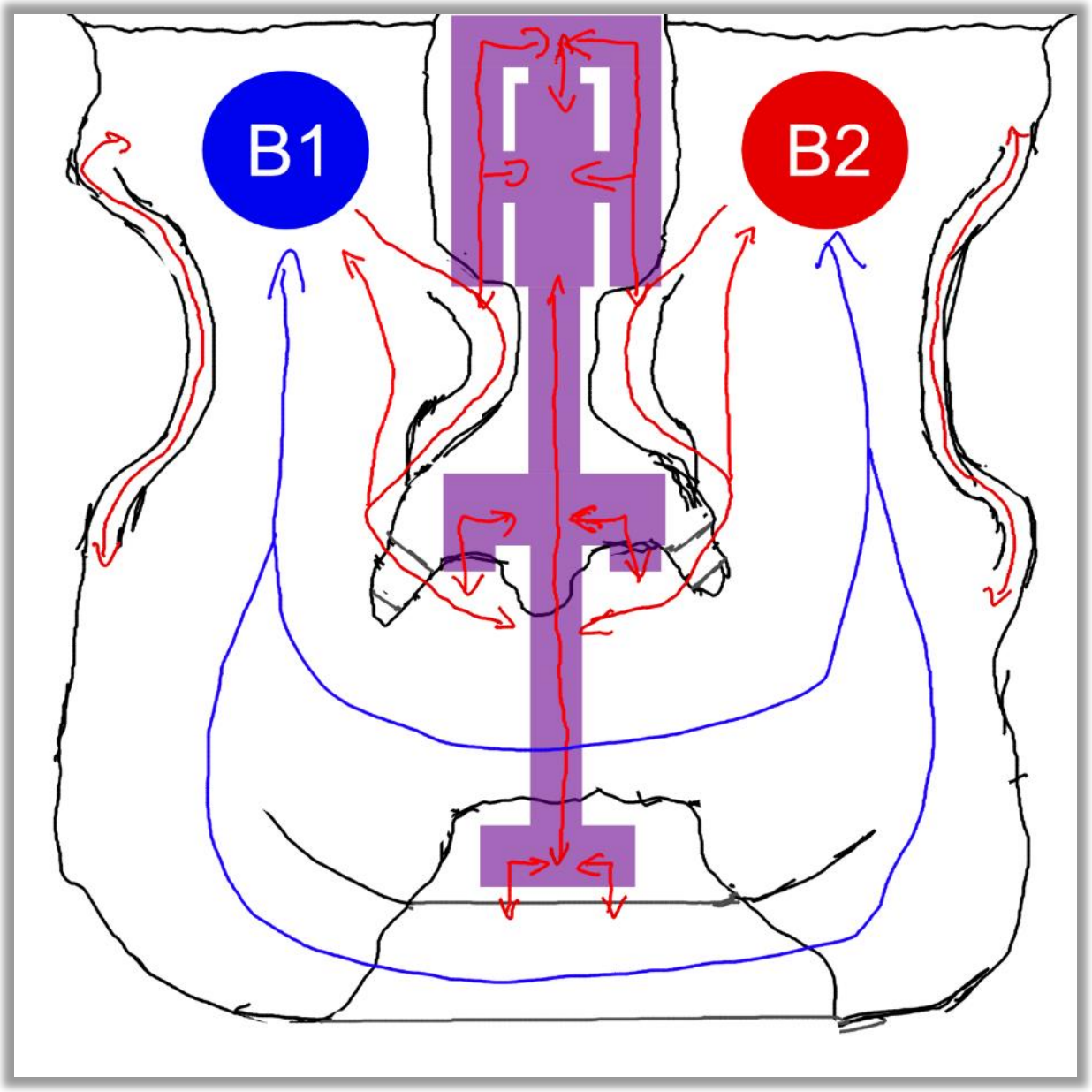

Figure 12 – Pegasi Delta map concept art version 1

A second revision of this design was created to solve initial issues with the design after preliminary map sculpting.

The most apparent issue was the barren space on the south west and south east corners of the map. Players would be less inclined to use the outside routes around the map unless using much faster vehicles.

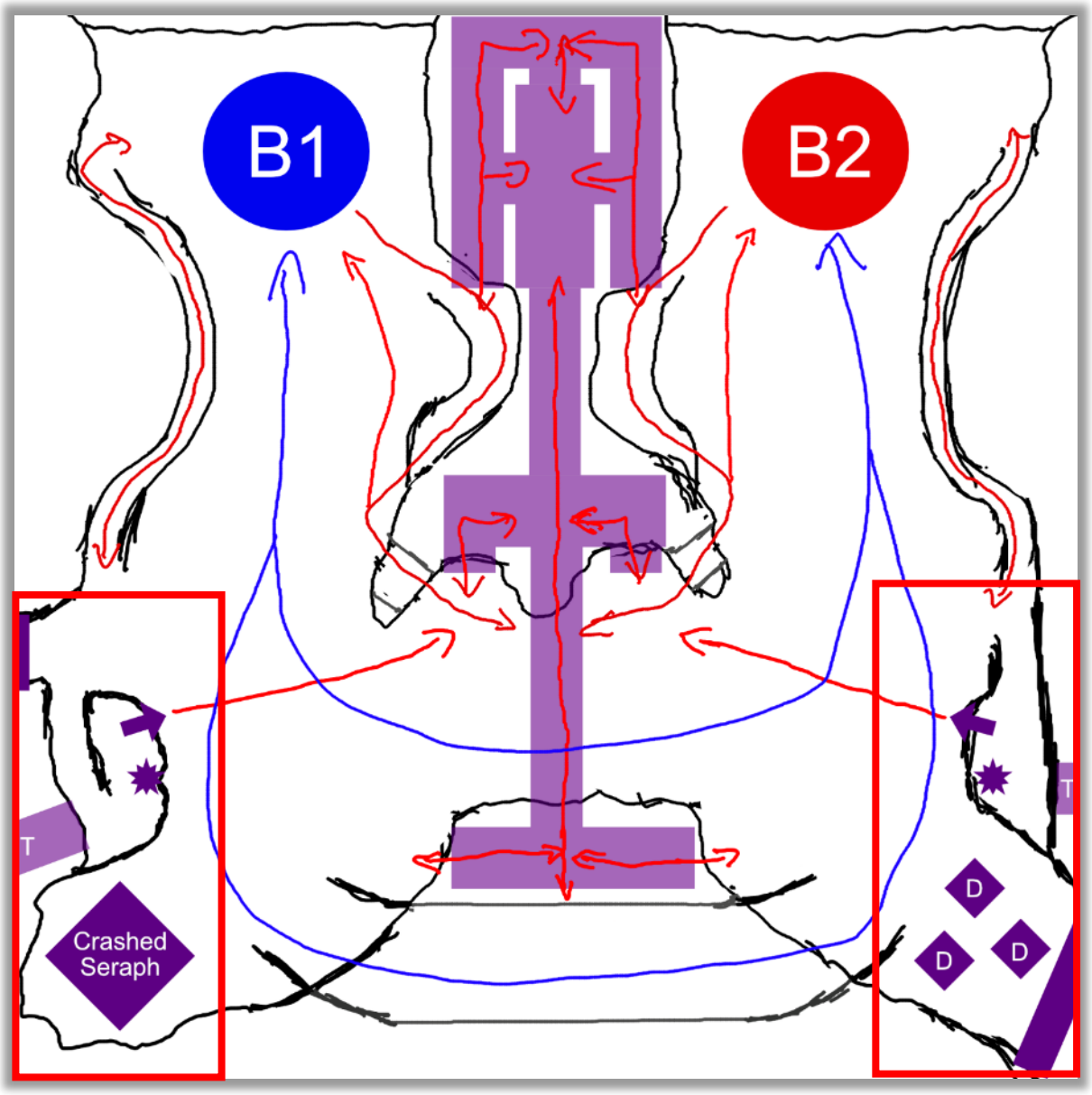

Figure 13 - Pegasi Delta map concept art version 2

In revision 2 (figure 13), much of the southern part of the map has been redesigned to encourage players to use the southernmost corners of the map. Ridgelines were added which would incorporate a stationary turret as well as a 'Man Cannon' which on contact, sends the player towards the centre of the map, improving player mobility while on foot. To further aid mobility, a two-way teleporter was added from this ridge to the nearby player base

Variations to either side of the map were added so that players could better define what side of the map they're on. This should in turn make it easier for players to navigate the map. This technique is known as 'Weenies' and was first used by Walt Disney in Disneyland. The left side of the map would

make use of a crashed Covenant fighter (Seraph), while the right side would use stealth orbital drop pods, as discussed in the Halo novel 'Ghosts of Onyx'.

The player base designs of B1 and B2 were drawn out. As these buildings were designed to be of Covenant architecture, the design and layout of these bases on a Bungie designed Covenant map, Assembly.

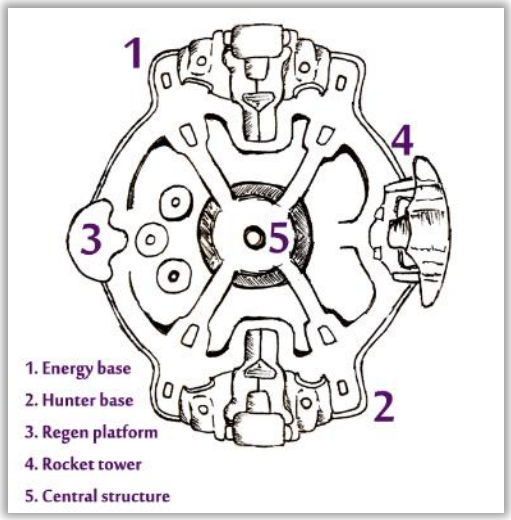

Figure 15 – Assembly map from Halo 3 Top Down (Krono101, 2010)

Figure 14 – Assembly map from Halo 3 (Phaztic, 2010)

In addition to the Assembly influence, the player base designs were heavily influenced by the structures used in Halo's most famous multiplayer map, Blood Gulch (figure 16). These structures are circular and should be recognisable to Halo players (figure 17 & 18).

Figure 16 – Player bases from the Blood Gulch map in Halo: Combat Evolved (Delta4907, 2010)

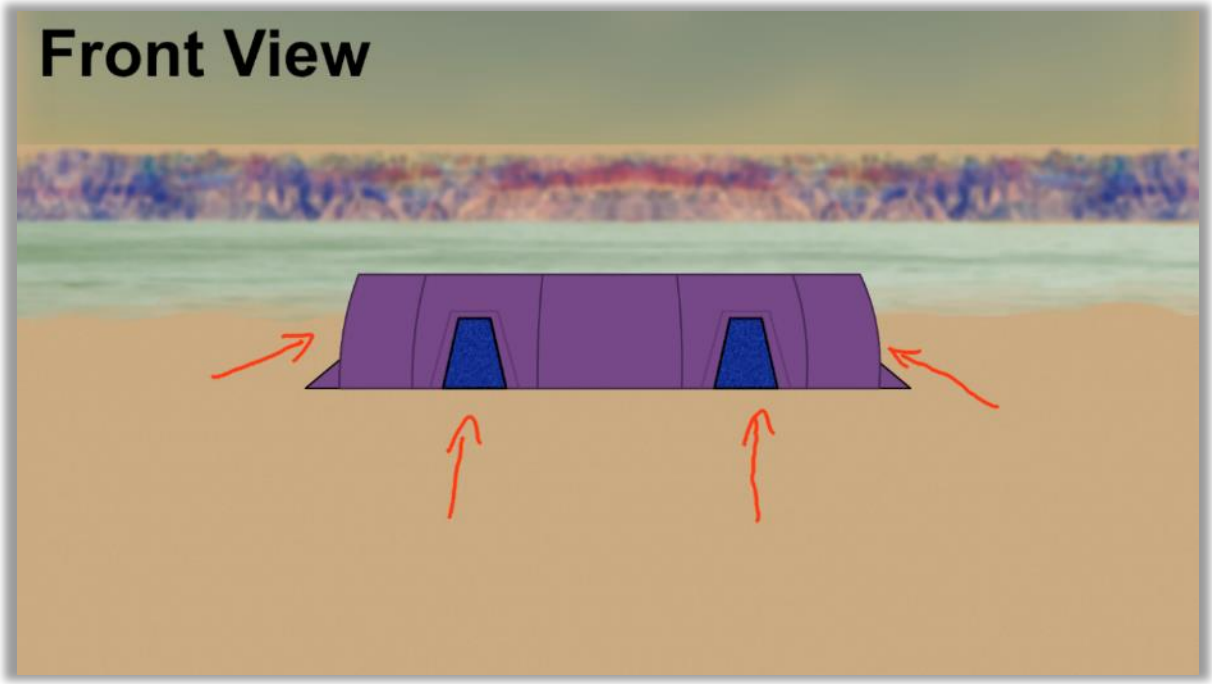

Figure 17 - Player base front view concept for Pegasi Delta

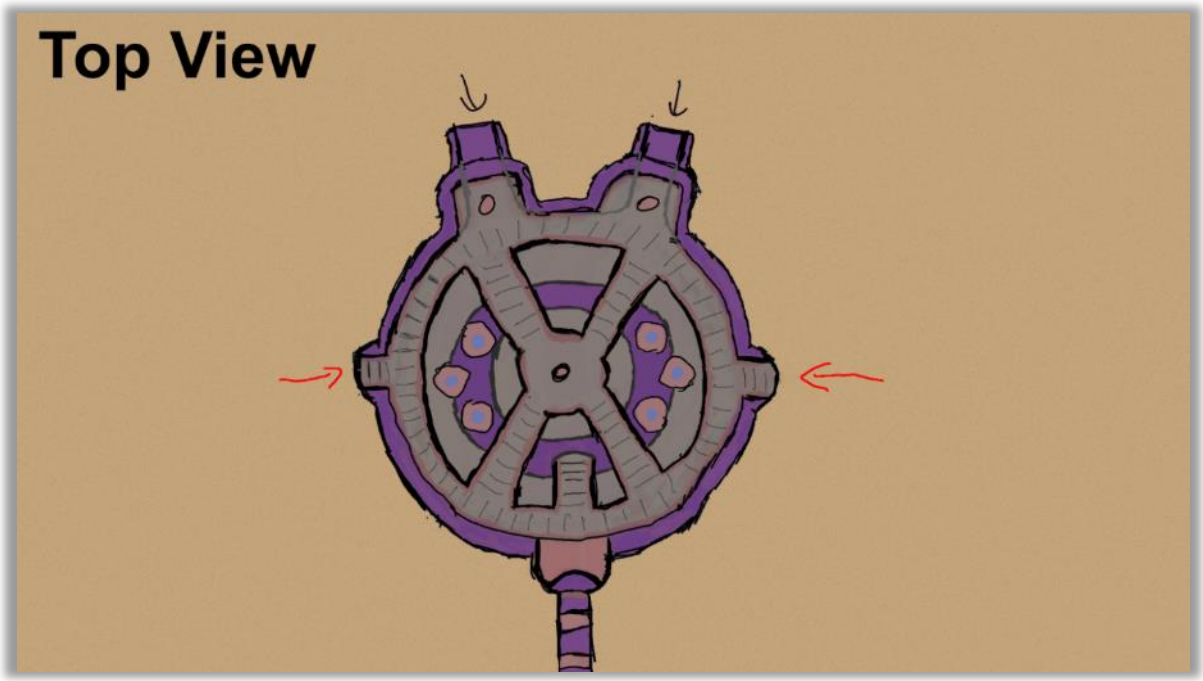

Figure 18 – Player base top view concept for Pegasi Delta

3.1.4 Block-out

The next stage was to block out the level. This was done using the landscaping tool and some tertiary meshes including a variety of rocks and cliff faces. These would all be edited to better suit the levels theme. To accurately sculpt the landscape from the top down design, the concept images were imported into the scene and placed in the orthographic view. BSP brushes were used to create the block-out for static meshes such as the bridge and interior structures.

The map underwent some final revisions as the two newly introduced ridge lines had direct line of sight to one another. This could cause imbalances in the game if a player had a long-range weapon such as a sniper rifle as they would be able to shoot the opposite ridgeline with impunity. This imbalance needed to be fixed for reasons discussed by Elizabeth Schwartz in section 2. A variety of options were considered.

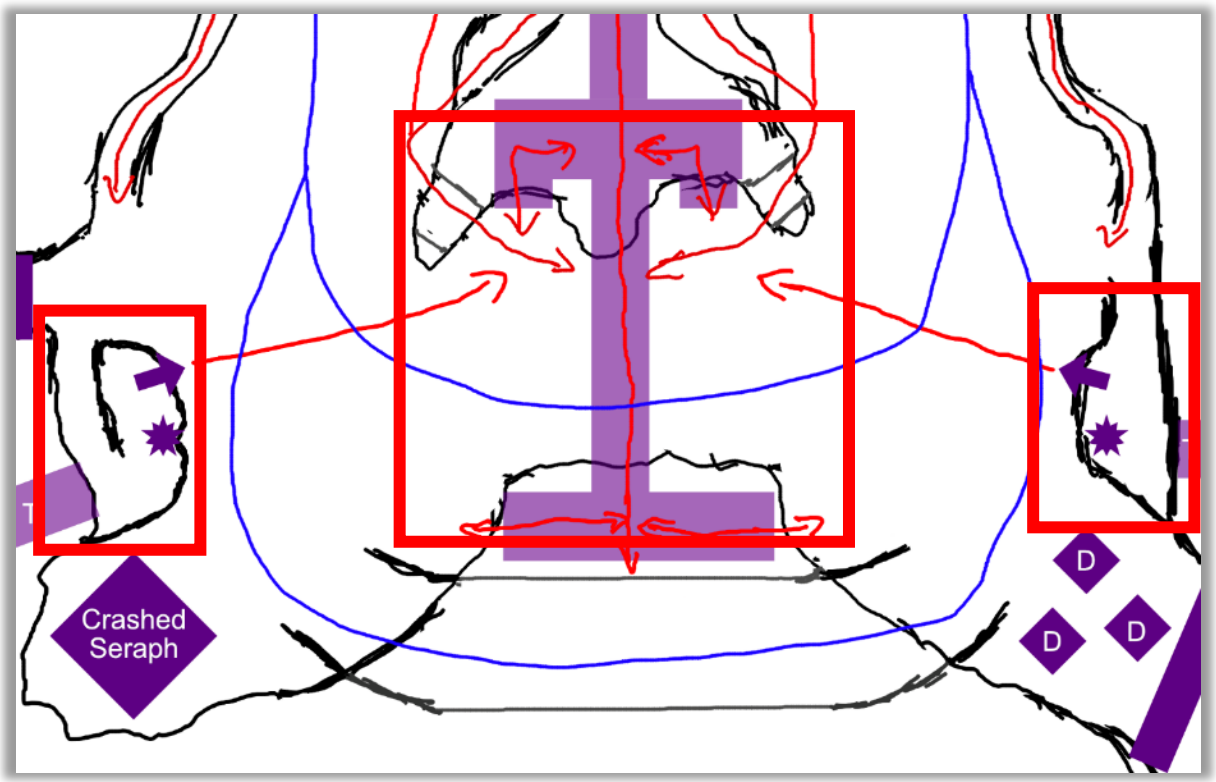

Figure 19 – Area of Pegasi Delta needing redesign/fix

Option 1 was to reshape the maps layout by moving the cliff faces found in the centre (highlighted in figure 19) further north or south. By moving this open area to the north, the game would lose the maps central interior structure. This would also mean that the interior corridor linking the southern and central part of the map, would also increase in length, causing further gameplay spaces to be added, which would in turn, dilute the impact of vehicles on the map. Moving the cliffs to the south would yield similar results.

Option 2 was to re-sculpt the central landscape and increase its elevation above the two ridgelines. This would stop players being able to shoot across the map but would look unrealistic, ruining player immersion.

The chosen solution was a less dramatic reshape of the cliff faces discussed in option 1, with the addition of a bridge crossing above the map from the south to the centre. The bridges legs/supports would help block the view. This wouldn't cover the opposing ridgeline fully but would allow for larger vehicles to still traverse the centre of the map (figure 20). Finally, a sandstorm effect would be created to make it hard for players to see one another from across the map.

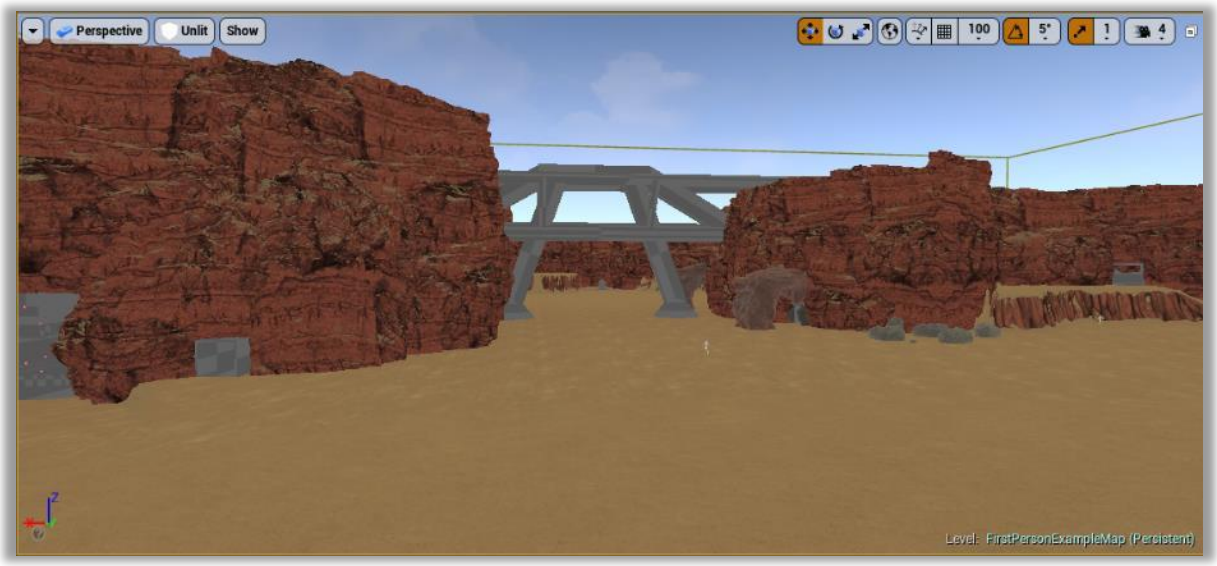

Figure 20 – Blocked out Bridge structure in centre of map

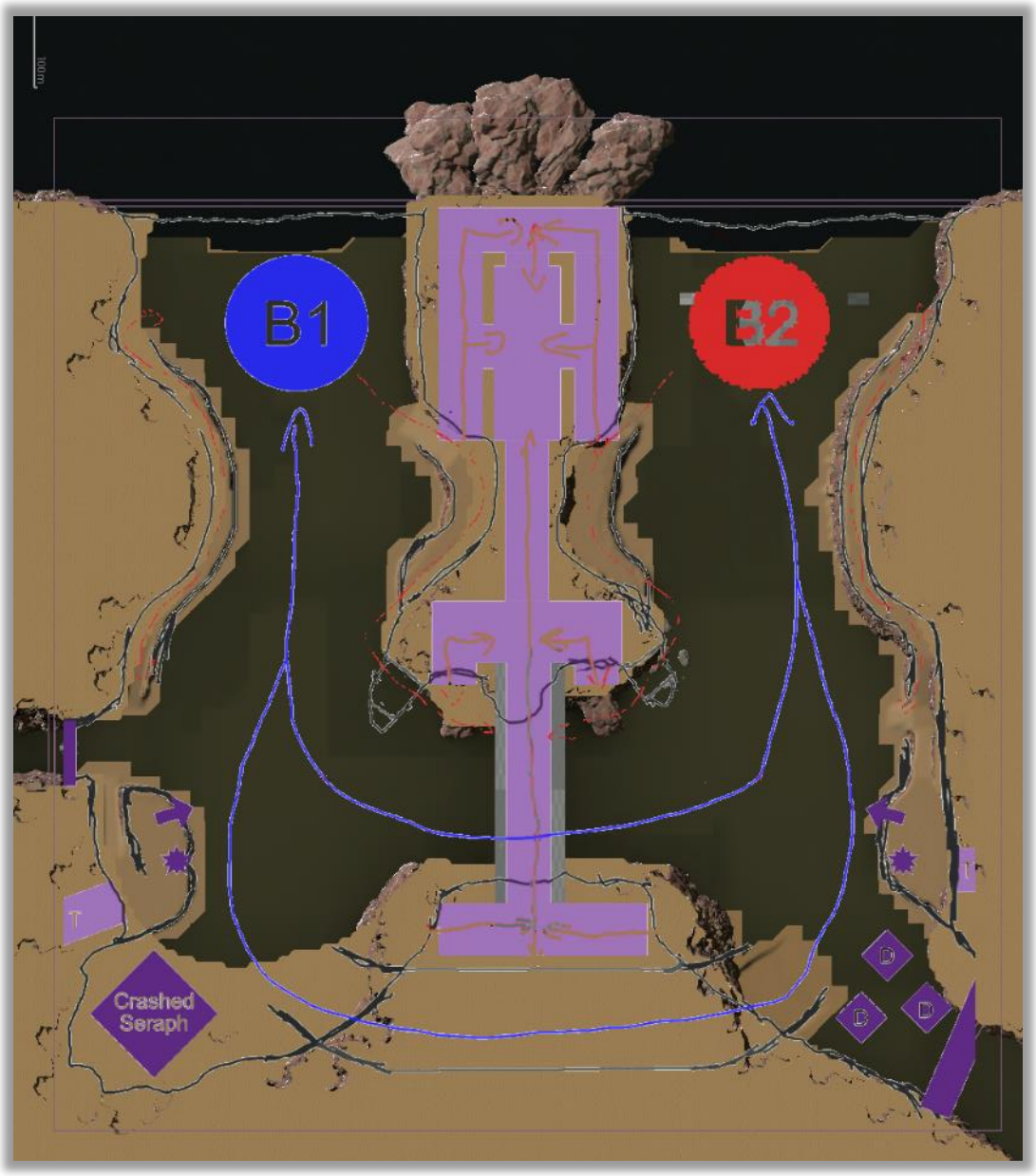

Figure 21 – Finished initial sculpt out of Pegasi Delta

3.2 Development of Art Assets

During the preproduction stage of development, a small asset list had been created identifying major assets that were going to be developed for the level. However, the assets list was changed as the map altered from solely Covenant architecture to a mix of primarily Covenant and some UNSC (human) architecture. Old and abandoned UNSC architecture would be found on the south side of the map while the northern side and outskirts of the map would be Covenant architecture.

As stated earlier, it may not be as important to story tell in multiplayer maps. However, according to Bobby Ross (Ross, B., 2015) it "helps players to easily identify what the space is when its organised by narrative. This also makes for more effective player immersion". From research, this is the only multiplayer map to incorporate both UNSC and Covenant architecture in the same environment when compared to those developed in the Bungie era. This will make the map memorable as recommended by Games designer Scott Rogers (Rogers, S., 2014, p.416).

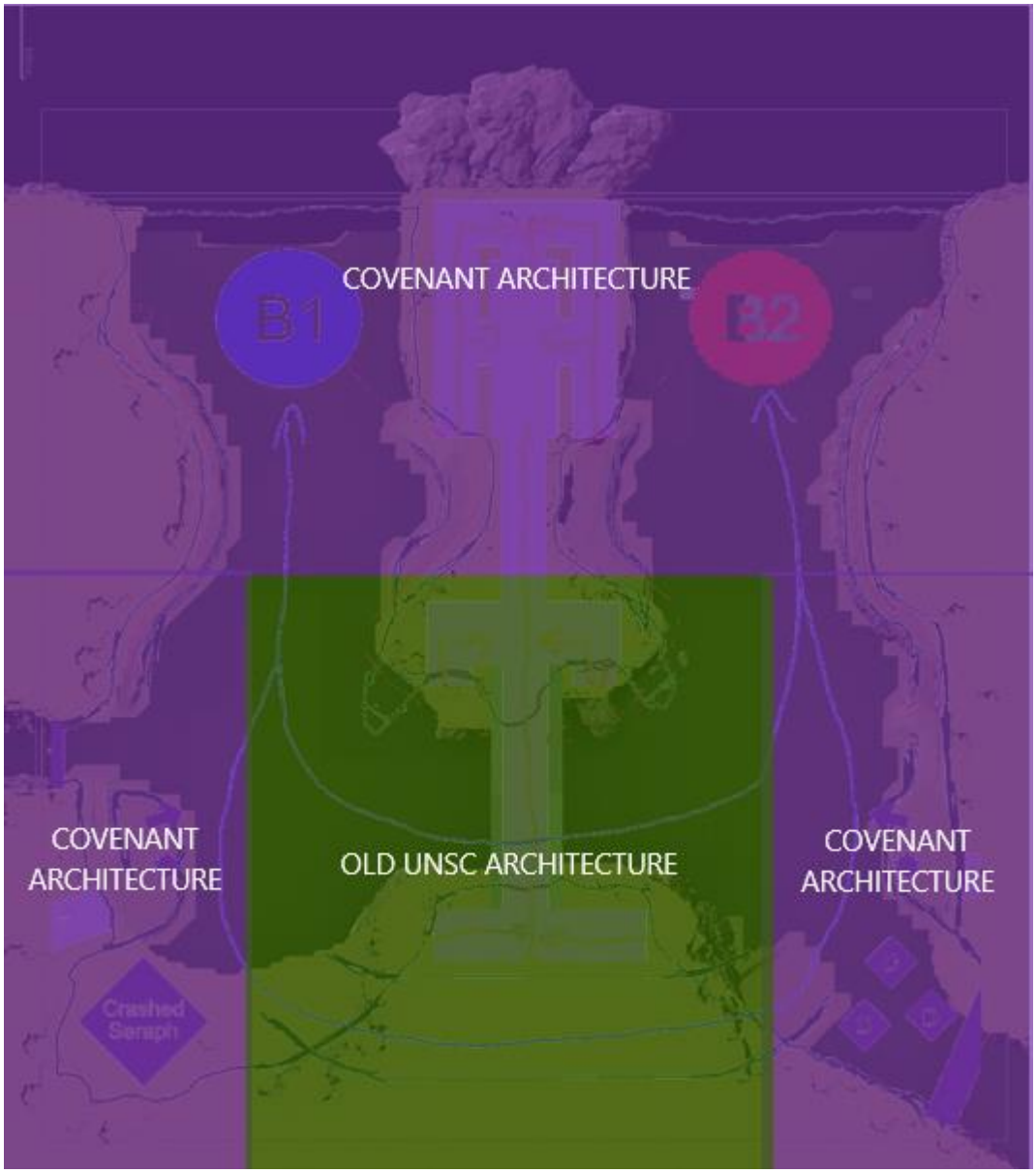

Figure 22 – Pegasi Delta's architectural balance

3.2.1 Collecting references

The first stage in asset creation was to collect reference material. As this project aimed to replicate Halo design under Bungie, most asset references were taken from either Halo 3 or Halo Reach. Models created for Pegasi Delta were placeholders designed to mimic the Halo counterparts. Few reference images were used in this project. Instead, a version of Halo was running while models were being created.

3.2.2 3D modelling

Autodesk Maya was chosen to create 3D assets as this program was the most familiar to the author. To better understand the pipeline used, the following is an example using the UNSC crate static mesh.

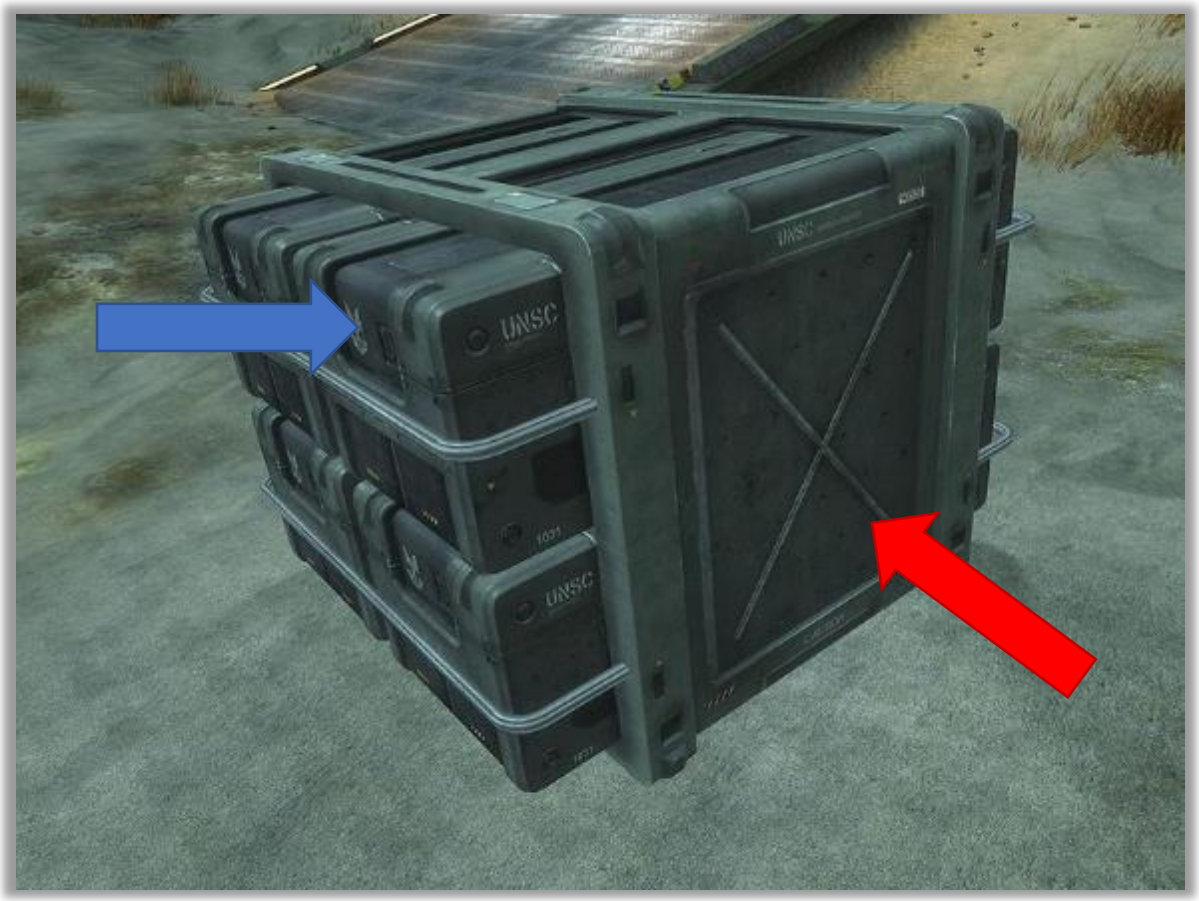

Figure 23 – UNSC crate from Halo Reach (Jugus, 2010)

Initially, the model was boxed out using measurements found in Halo Reach or the Halo: The essential visual guide by Jeremy Patenaude (Patenaude, J., 2011). The basic topology of the object was modelled first with details, such as the rubber pads and curved edges modelled later using tools such as bevel.

Performance is key in multiplayer levels and should always aim for 60 frames per second. To improve performance each inner container (blue arrow) was identical as well as split in half (figure 24, figure 23).

The containing unit (red arrow, figure 23) would also be split in half (figure 24). This means when UV mapping, the model requires less UV which means the model can have a higher UV resolution for a great fidelity or can use a smaller sized texture sheet or share its texture sheet with another model to save memory, improving performance. This technique was used by the author while working for Blueprint Digital Media on placement and was applied to the large container by fitting a small container model on the same texture sheet.

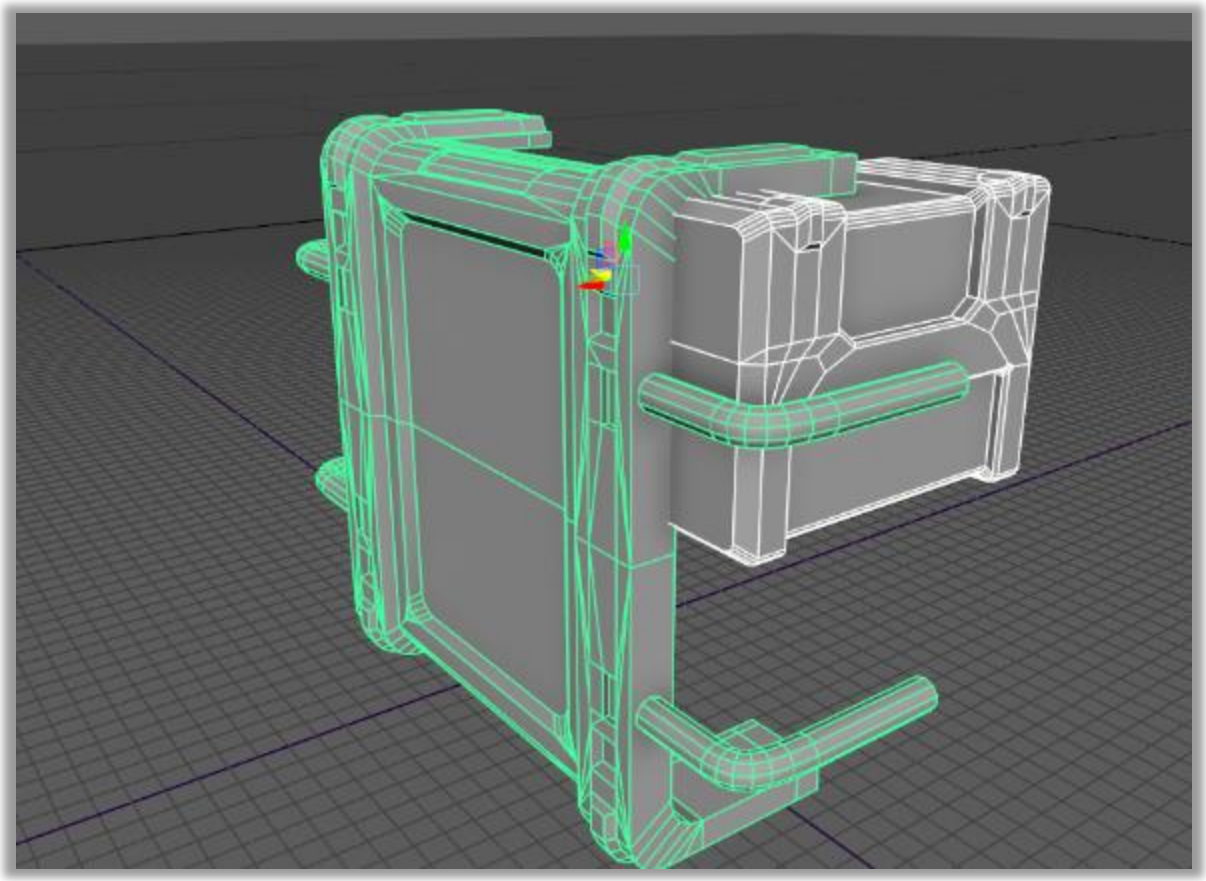

Figure 24 – UNSC crate before mirroring

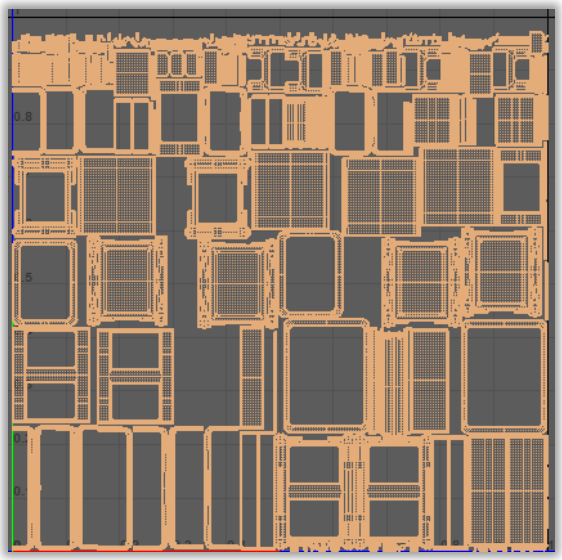

Figure 25 - UNSC crate Automatic UV map

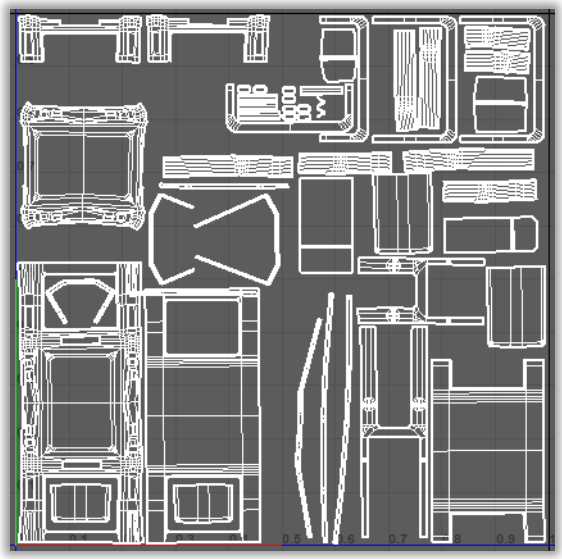

Figure 26 UNSC crate Manual UV map

The final stage was to mirror the assets for the containers to create the whole asset (figure 27).

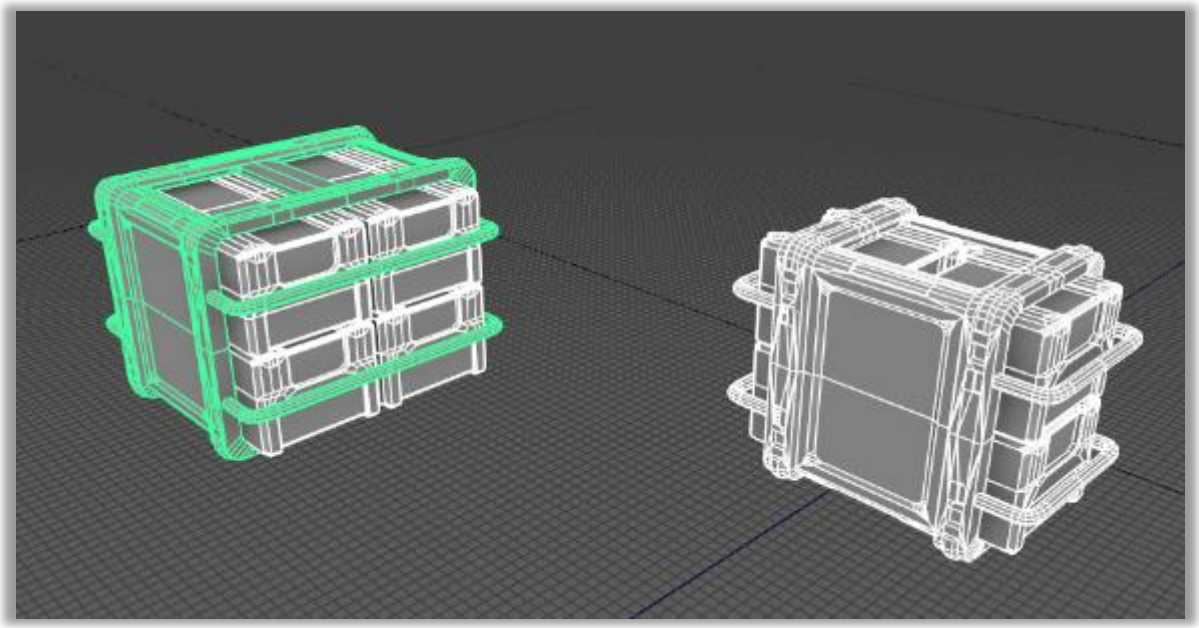

Figure 27 – UNSC crate large & small mirrored

Another modelling technique applied was the use of modular asset packs. This technique is where assets are created to a set size or scale (for example, the object must be a size of 1*1*1). In this project, this technique was applied for assets such as walls, ceilings, floors as well as various pipes. The creation process of these assets were the same as crate, however, the assets must always fit within limitations/specifications that were chosen for the whole pack.

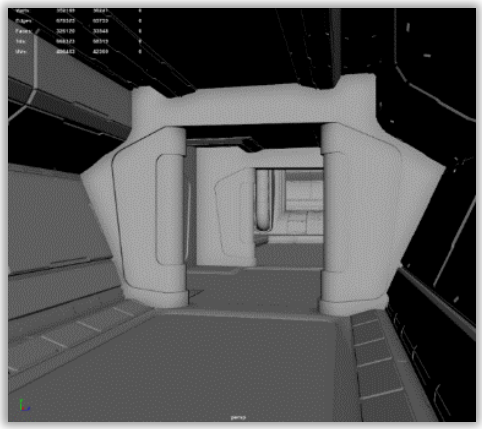

Figure 28 – Modularised Covenant Corridor pieces

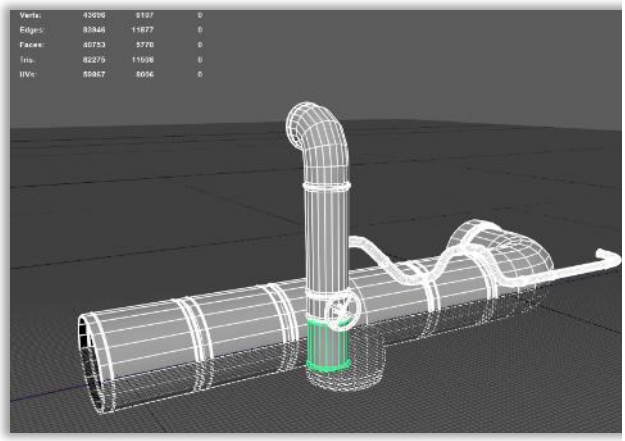

Figure 29 – Modularised UNSC pipe pieces

Modular asset packs in the project are all modified from one initial piece. For example, the large pipe pack was created from a basic pipe model that would fit into a 2x2 grid. To make another modular piece, the length was doubled while retaining the same scale. It was important for the pivot point to be correctly positioned otherwise the pipes will not easily snap together. Figure 30, 31, 32 depict modular pipes fitting together.

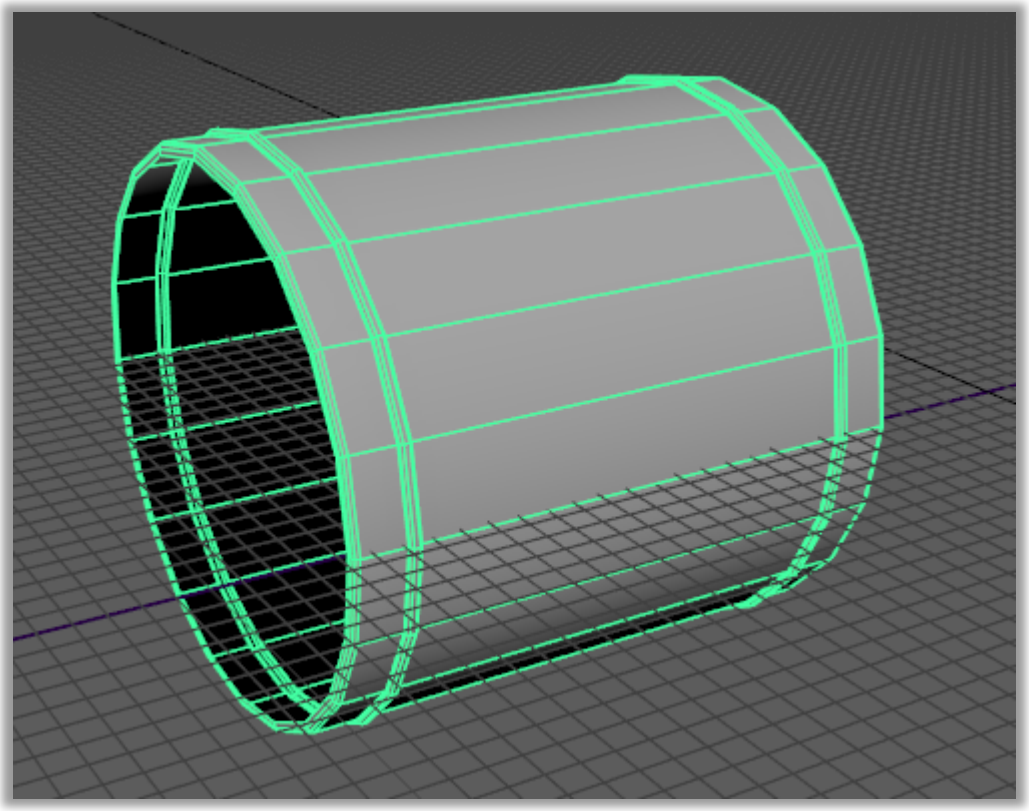

Figure 30 – Modularised Pipe piece 1x1x1

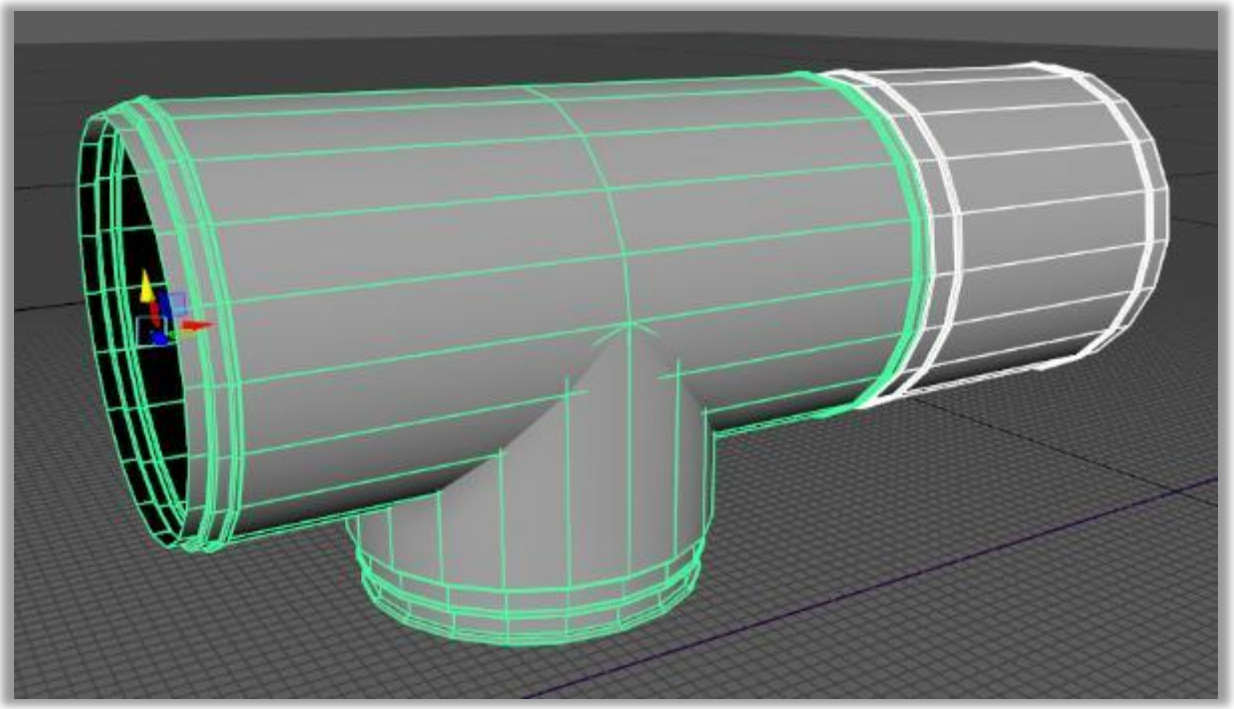

Figure 31 – Modularised Pipe piece 2x1x1

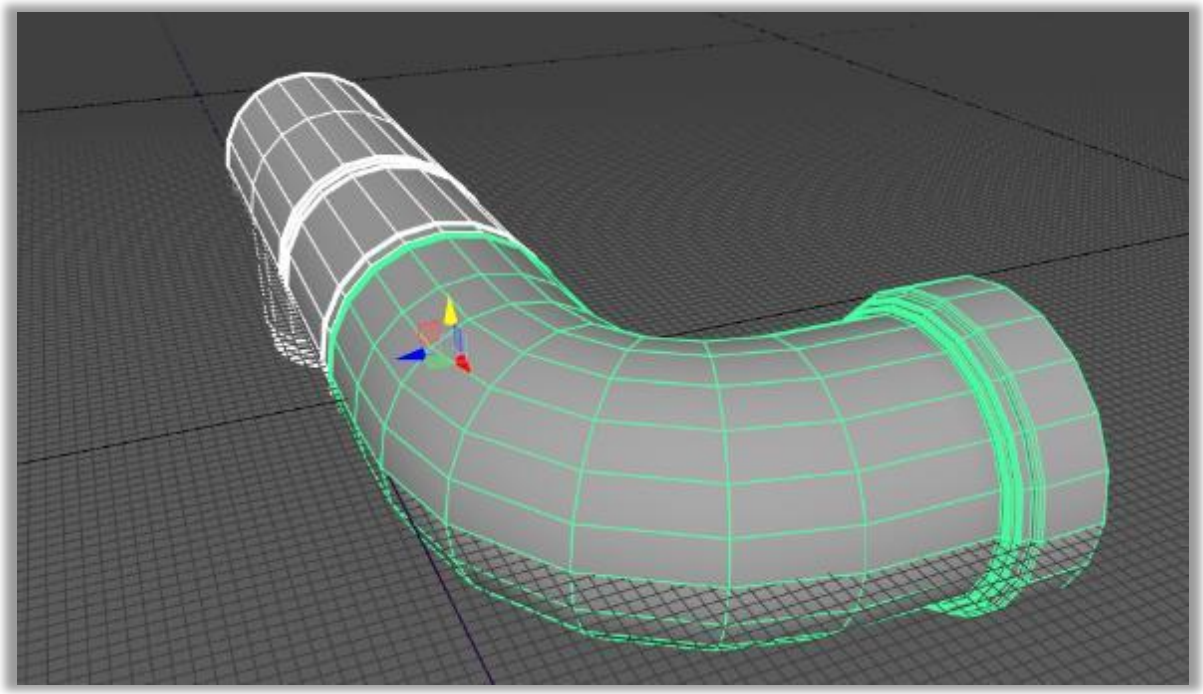

Figure 32 – Modularised pipe curve piece 2x1x1

3.2.3 Texturing

For reasons highlighted in section 2, Substance Painter was used for texturing in this project. The crate model will be used to demonstrate the workflow.

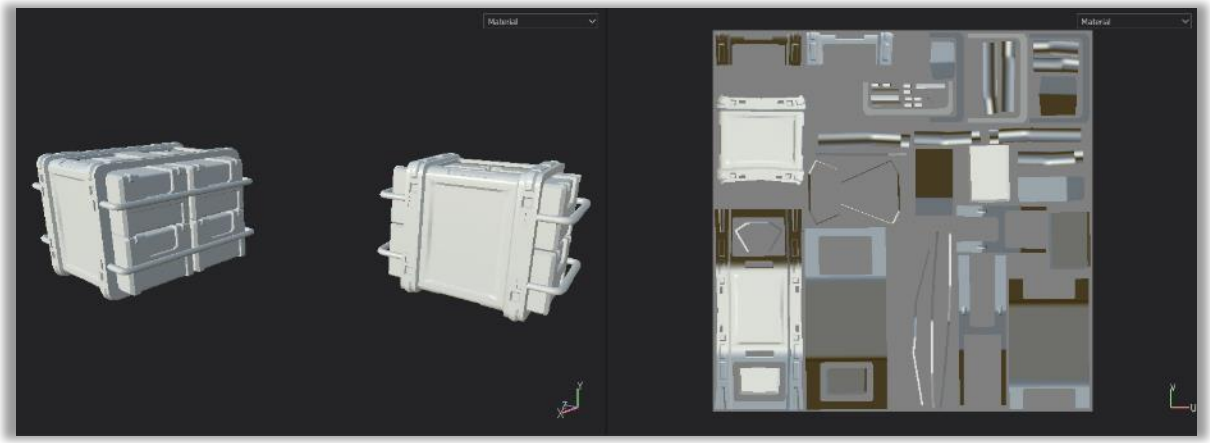

Figure 33 – UNSC crates imported into Substance Painter with UV map

As the crate is large and shares the sheet with another mesh, the largest commonly supported sized texture sheet of 4096 x 4096 pixels was used.

Substance Painter has a variety of pre-set materials including metals, woods, plastics and fabrics. For the crates, a painter steel material was applied to the mesh. Areas of the crate which needed other materials applied were masked out. On other meshes, normal maps would be applied to add 'fake' detail.

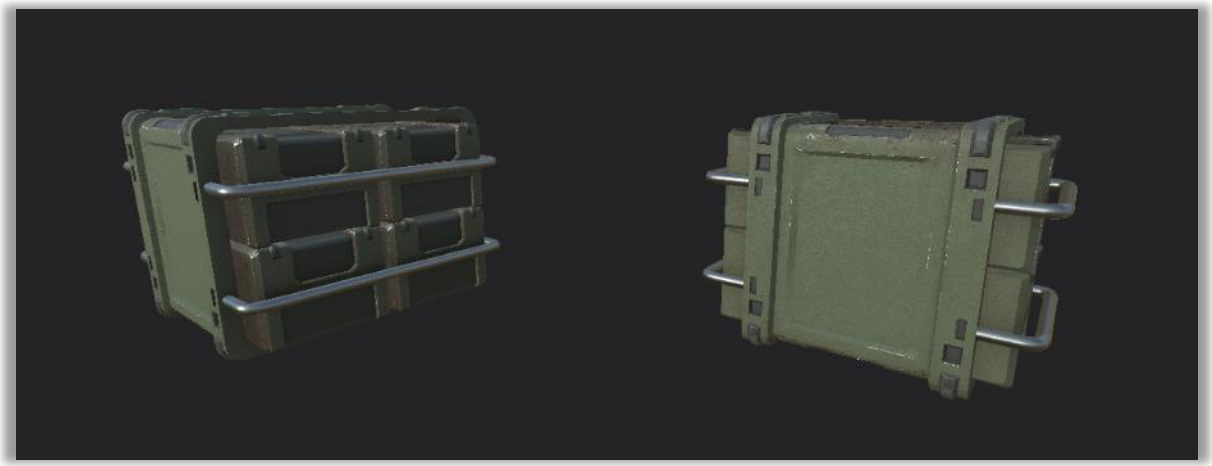

Figure 34 – UNSC crates textured in substance painter

The final stage is to add the generated textures. As the crates are designed to be old and abandoned, this meant adding a mix of dirt and sand on top of the base material (figure 35).

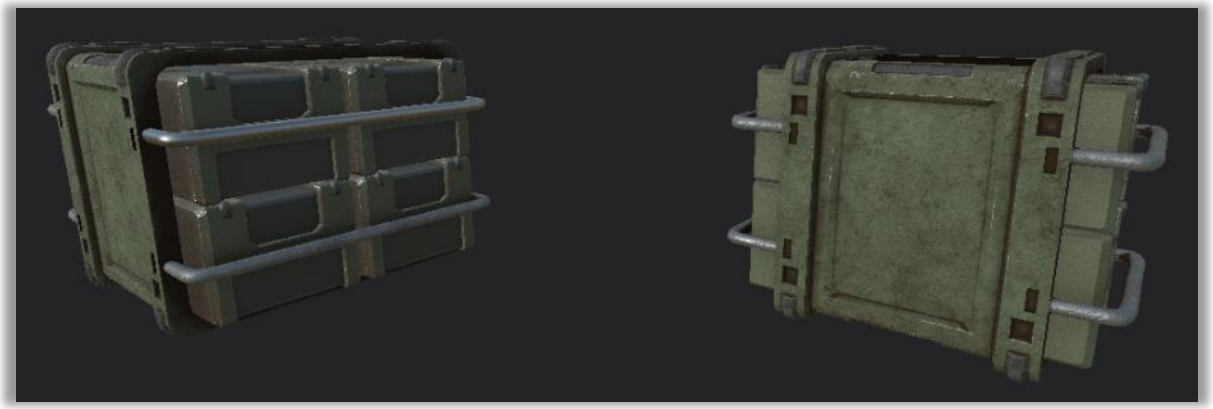

Figure 35 – UNSC crates textured with dirt detail in substance painter

The textures were then ready to export to UE4. Different texture sheets were exported holding Colour, Opacity, Normal, Metallic, Roughness and Ambient Occlusion data. If a static mesh had an emissive value, then a separate mask would be exported and used in UE4.

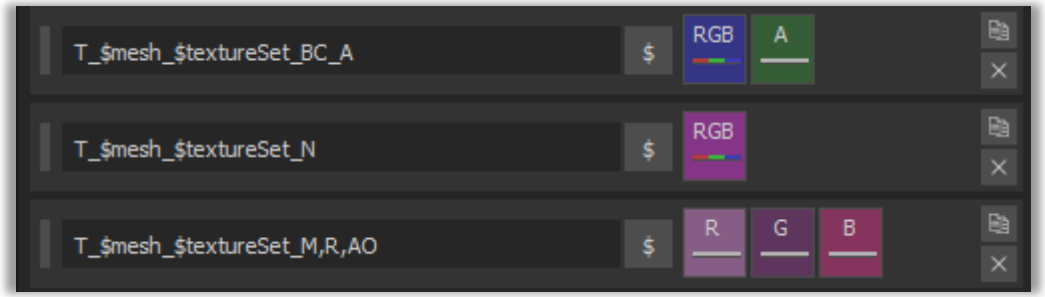

Figure 36 – Substance Painter export configuration

3.3 Implementation of Art assets in level

With art assets developed, they were now imported into UE4. This can be highly time consuming as discussed in chapter 2. This section will discuss the reasoning and processes of implementing art assets into the Pegasi Delta map as well as additional changes made to the map. Furthermore, this section will discuss the material creation in UE4.

3.3.1 Placing Art Assets

When importing static meshes and textures, each item needed its settings manually adjusted. For example, when importing texture sheets, UE4 can often select the incorrect pre-set for the texture sheet. UE4 often sets the texture map containing Roughness, Metallic and Ambient Occlusion to a Normal map pre-set. This radically changed the way in which the texture was rendered.

Larger assets such as the Bridge and the player bases had their locations defined at specific points of the map from the early development of the level. Smaller assets had no fixed locations, instead they could be moved feely within the constraints of the architecture used in an area. These assets were also placed to solve arising gameplay issues.

Figure 37 – Pegasi Delta vehicular tunnel with asset place holders

Figure 38 – Pegasi Delta vehicular tunnel with art assets placed

While map exploits can be found during user testing, some will be identified in this phase of development without user testing. To break up the centre tunnel of the map, a UNSC storage room had been created. In the centre of the room was a 2x2x2 stack of large crates. However, this lead to players (P1 & P2 in figure 40) being able to shoot between the gap created by the crates from a distance where a player may not be seen.

Figure 39 – Original asset placement – bad design

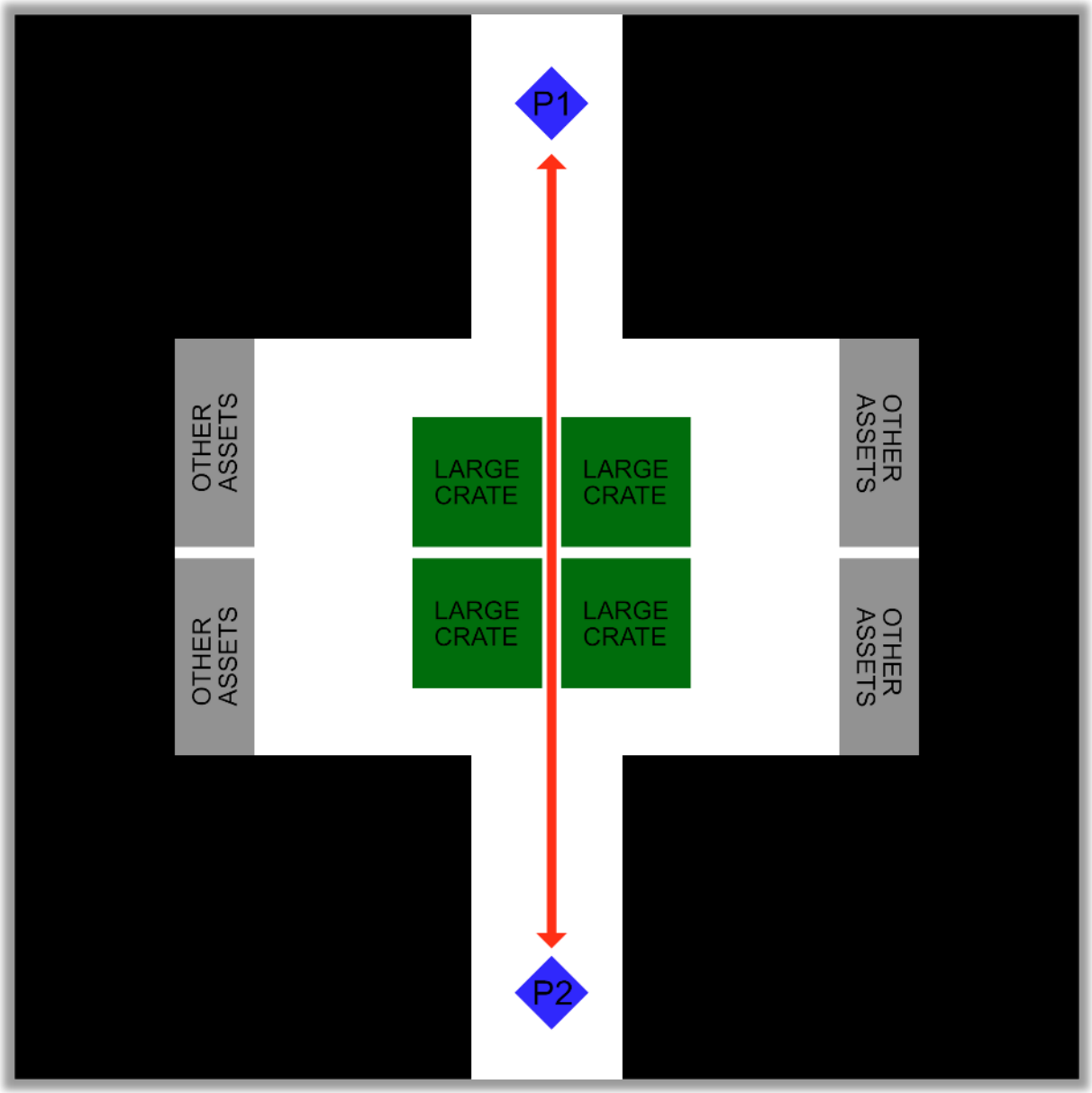

Figure 40 – Original asset placement – bad design diagram

To fix this, a column of the large crates was removed, and the remaining large crates centred. Then to either side of the large crates, two small crates were added (figure 42, 43). This allowed this section to remain the same, playability wise, whilst removing the exploit.

Figure 42 – New asset placement – fixed problem

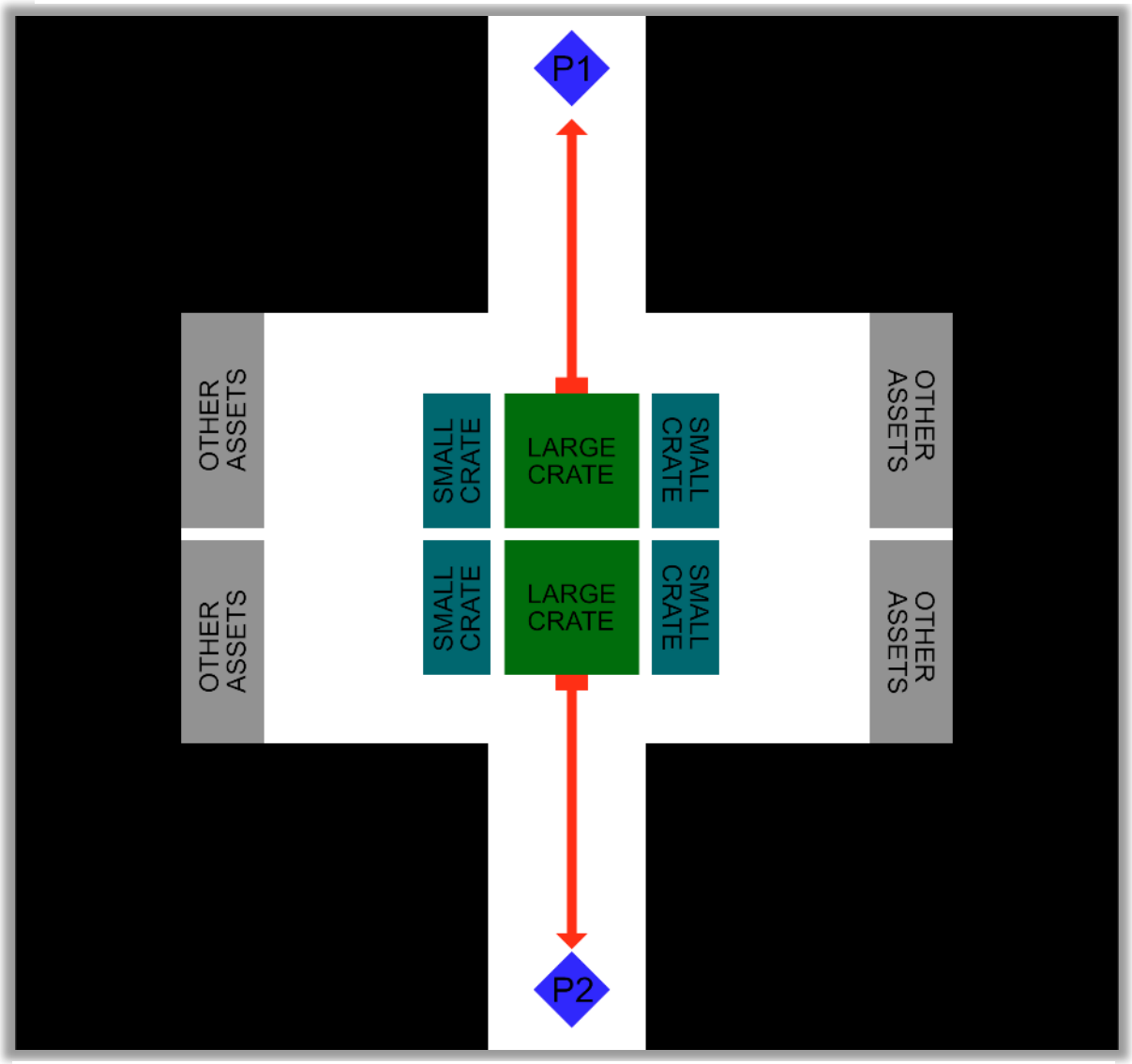

Figure 41– New asset placement – fixed problem

3.3.2 Material Creation

Materials were used to apply texture sheets to a mesh or to define technical parameters such as colour, reflection and transparency. For the most part, materials on Pegasi Delta were made up of texture sheets created in Substance Painter. This was done by connecting the applicable channels into the material node. In figure 43, an example can be seen for M_UNSCCrates.

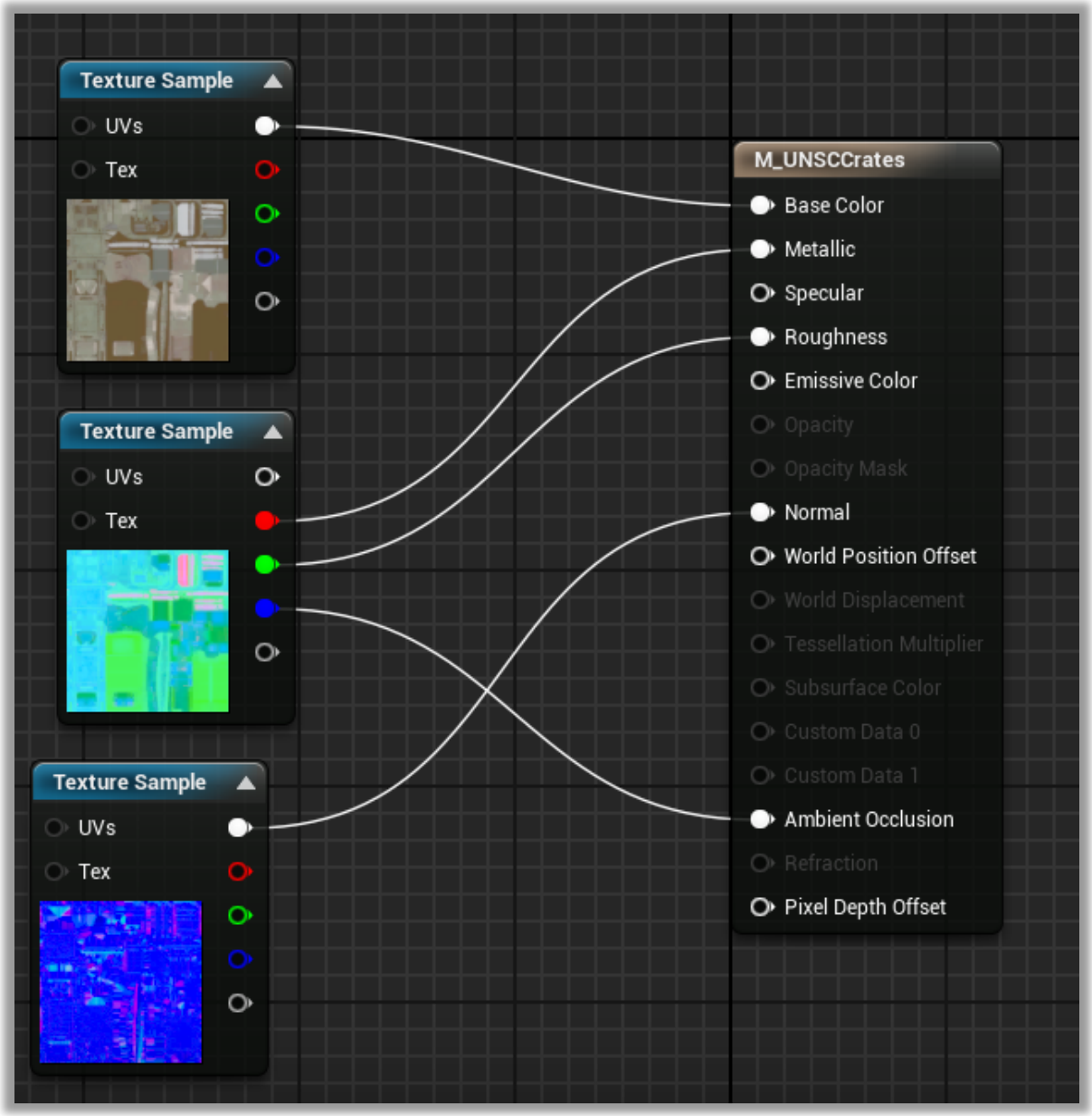

Figure 43 – Material M_UNSCCrates

It was also possible to mix these texture maps with the UE4 material parameters. This can allow for the modification of textures without the need to leave UE4. For example, in figure 44 below, a colour has been multiplied by a Mask to change the emissive colour of the M_UNSCLights material to the shown yellow/orange colour.

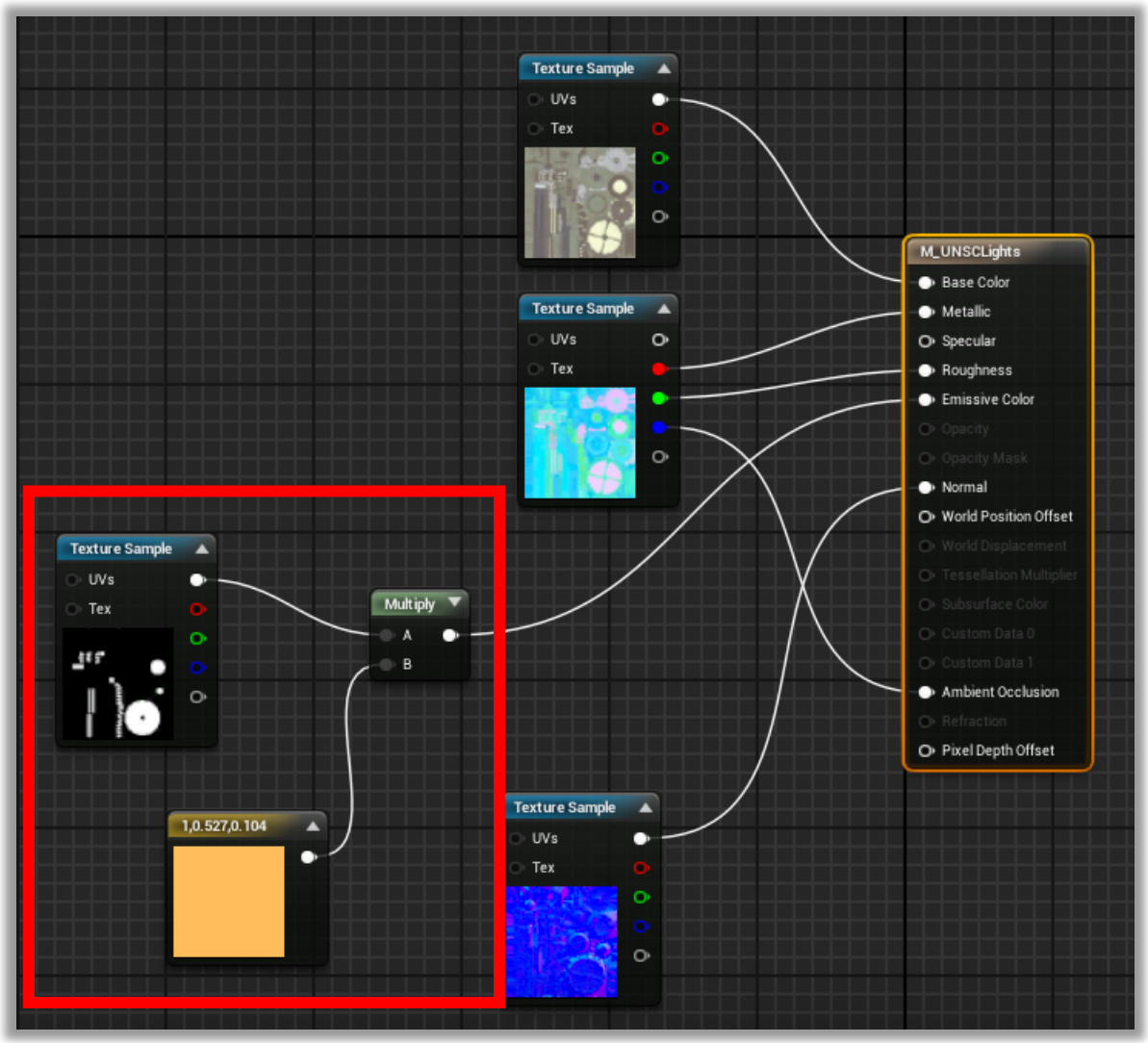

Figure 44 – M_UNSC Lights Material with emissive mask

It is also possible to create more complicated materials in UE4. Several of which were used in this project. Figure 45 shows a complex material used to create the heavy water for Pegasi Delta with the main areas of interest highlighted.

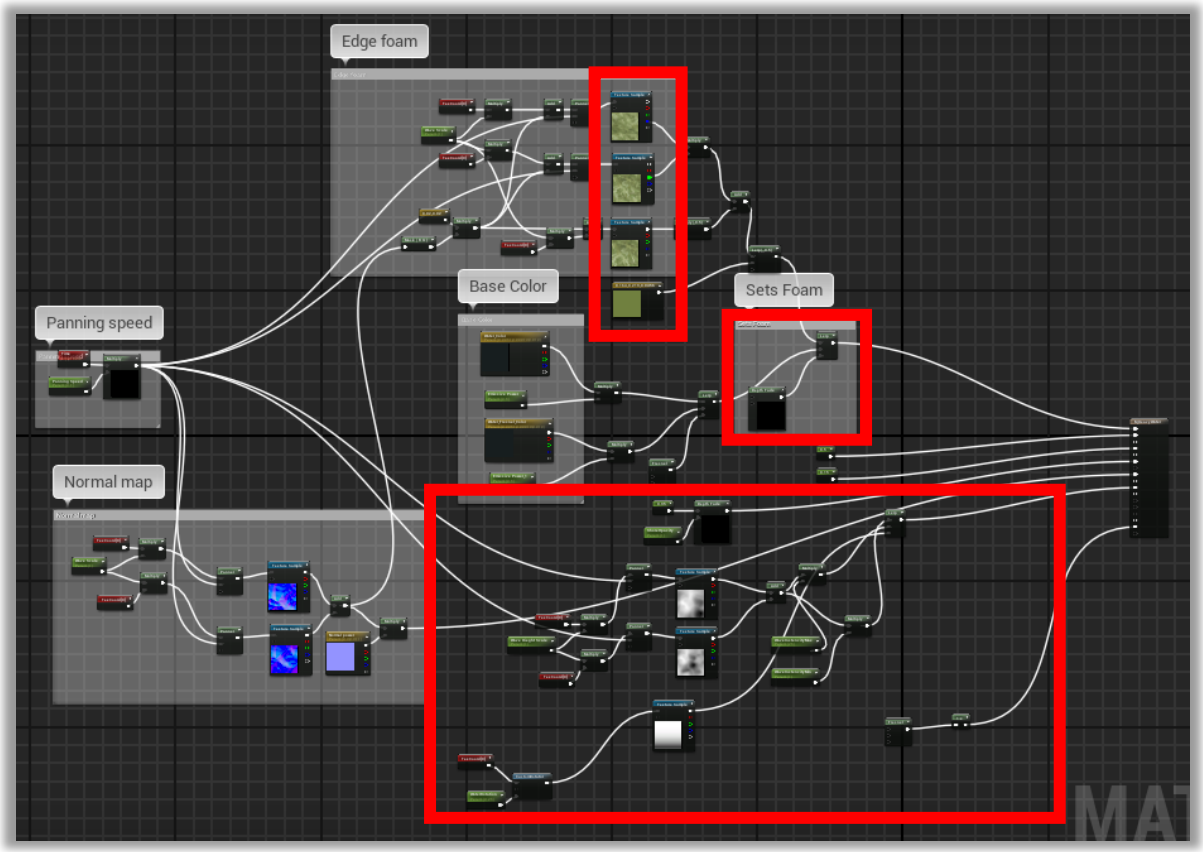

Figure 45 – Material for the Heavy Water

In addition to adding a lerp function (figure 46), the foam texture sheets were exported to a photo editing software and recoloured based on the heavy water colour found in Halo 3. This improved the colour blend of the foam at the shoreline.

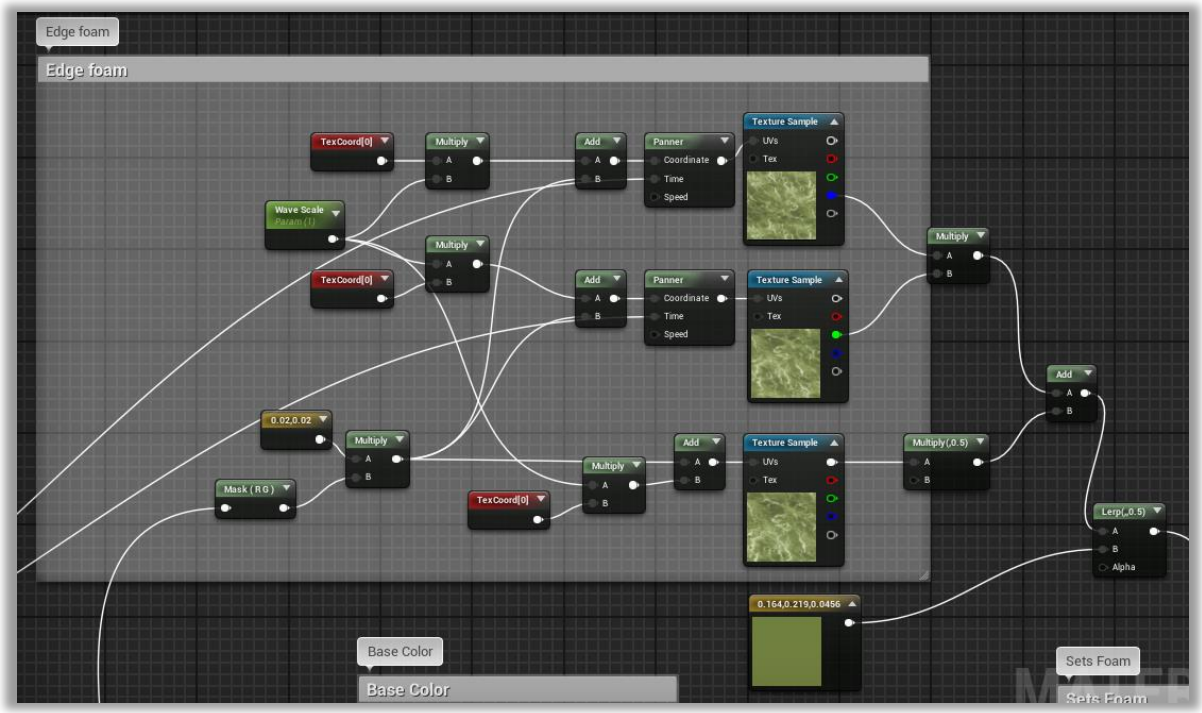

Figure 46 – Heavy Water material foam effect

Foam at the shoreline was applied using a depth fade which, when the depth of the water was at a defined level or less, the foam textures were used. This provided more consistency as opposed to when the material was applied using vertex painting (figure 47).

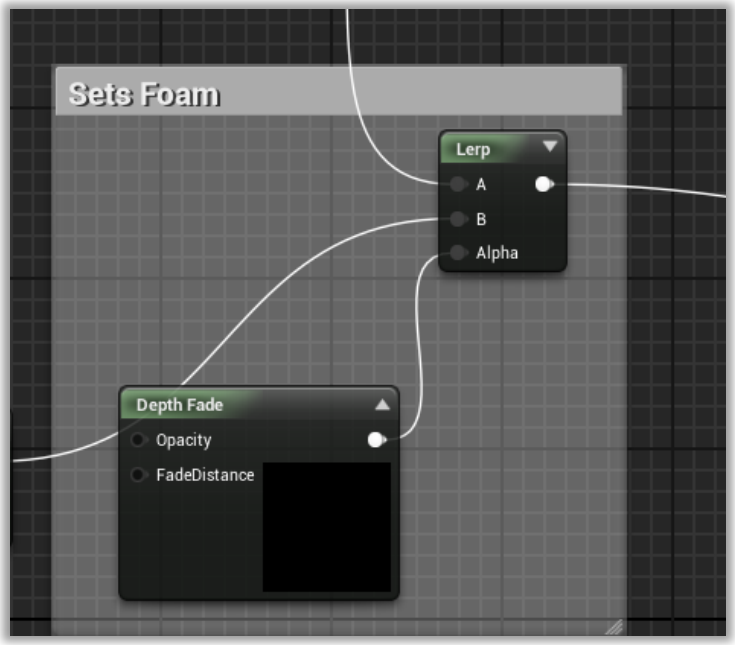

Figure 47 – Sets foam opacity based on depth

Creating realistic wave effects can be very computationally heavy, as many calculations need to be made as discussed by 3D artist, Hailey Williams (Williams, H., 2017). Therefore, a more primitive method was used. The method used greyscale, panning wave textures to define wave displacement. A custom gradient mask was then used to define the intensity of these waves over a distance.

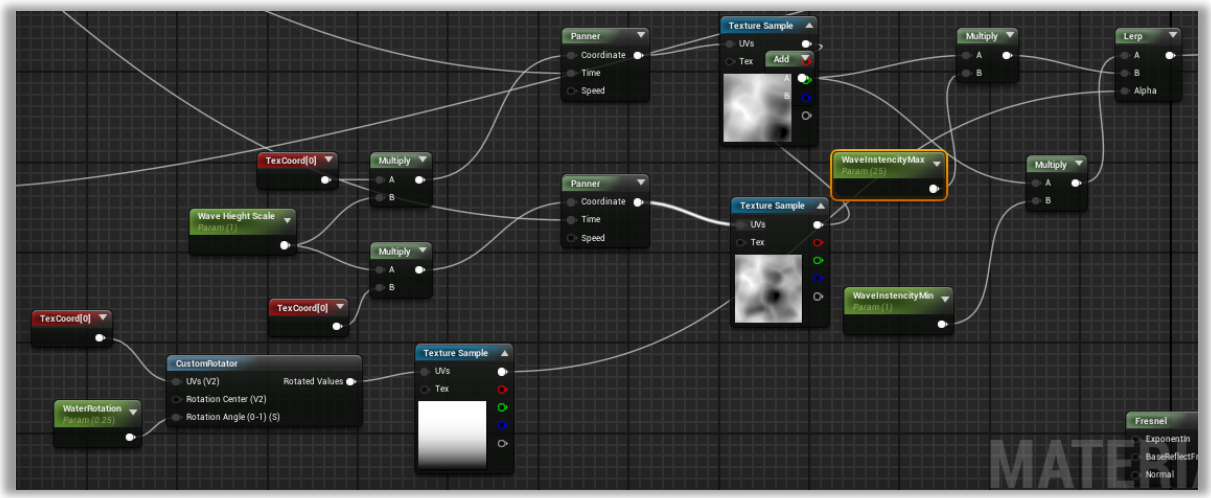

Figure 48 – Adds waves to heavy water material

Material functions were used to define four materials that would be used on the maps terrain. These textures were orange sand, lighter orange sand, wet sand and red rock. Material functions were used as it allows for individual parameters of a material to be accessed. Landscape painting was used as it allowed direct painting of materials onto the terrain.

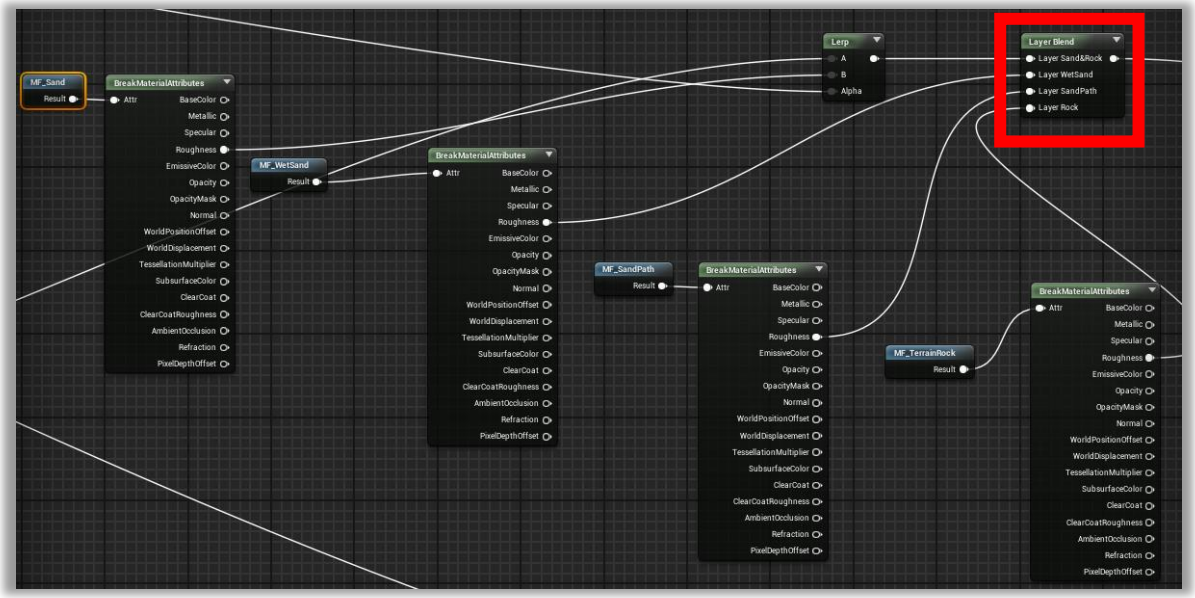

Figure 49 – Layer Blend node used to allow for terrain painting

For each parameter, a Layer Blend node was used to define each material in the landscape painting tool (figure 49).

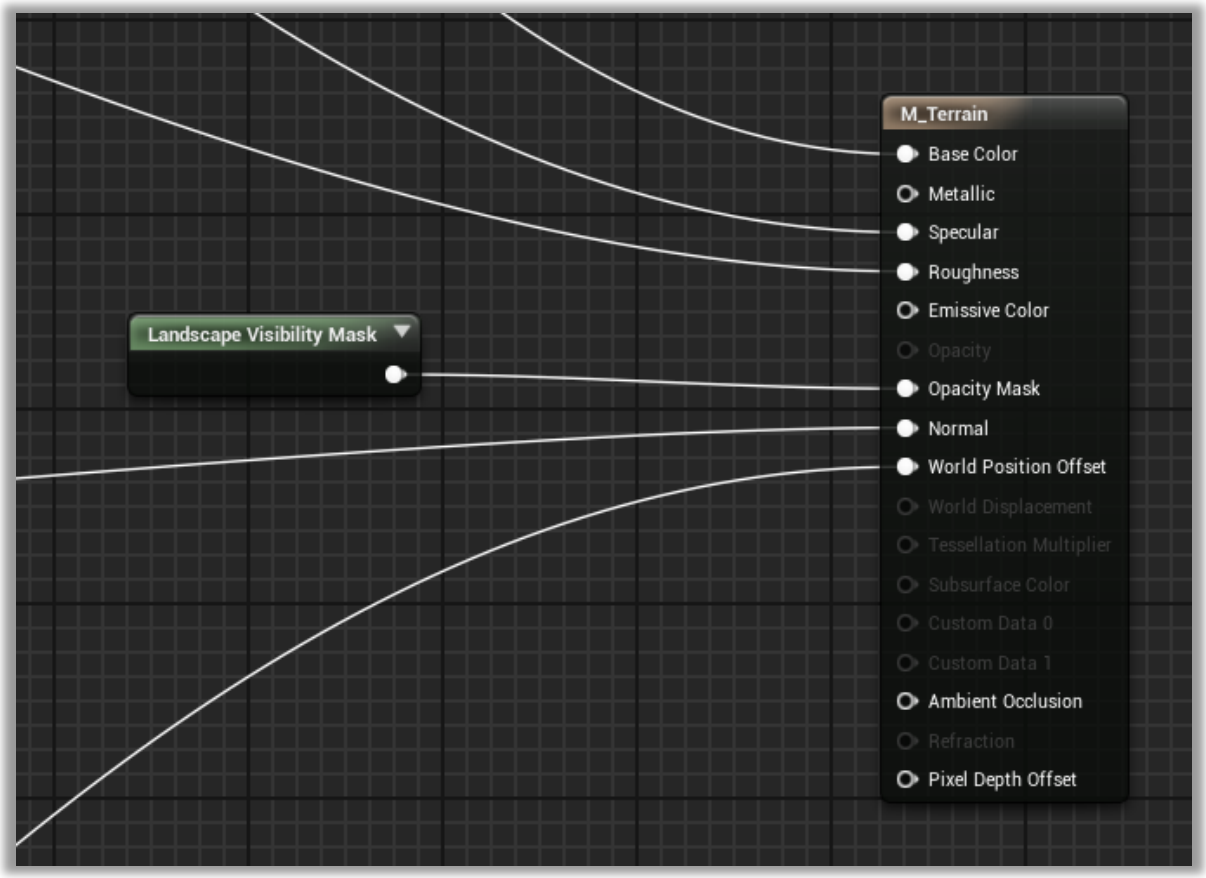

Figure 50 – Landscape Visibility mask node used to mask out terrain

The map uses an upper landscape terrain (figure 51, 52) which covers areas that are inaccessible to players. This landscape caused lighting issues as the upper landscape was blocking light from reaching the main, accessible landscape. Therefore, a Landscape Visibility Mask (figure 50) was added to the terrain material. This allows the user to mask out areas of the upper landscape which shouldn't be visible.

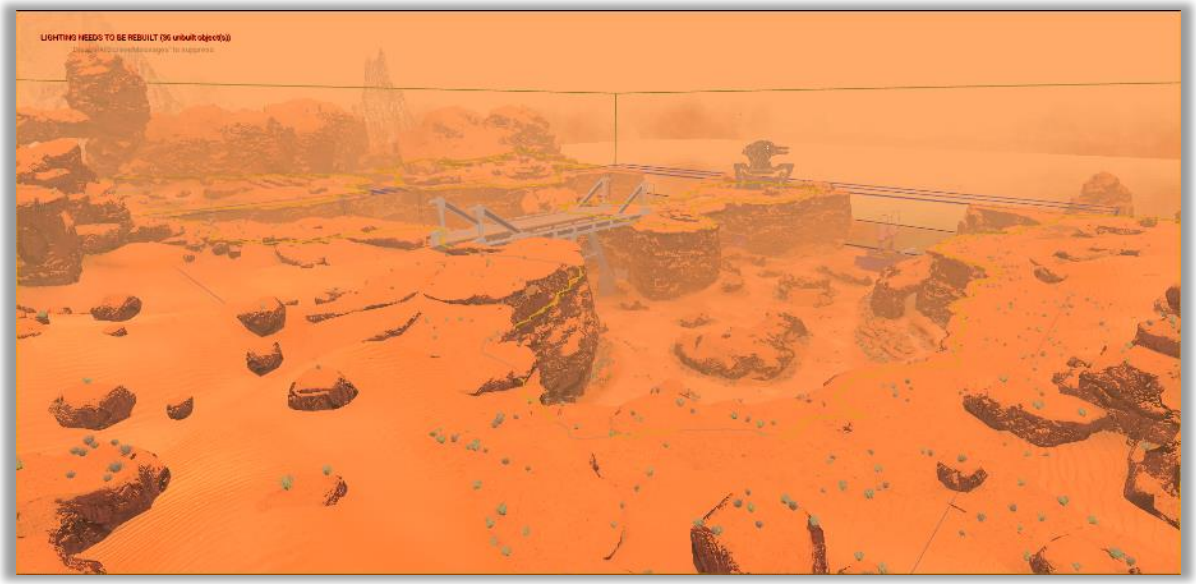

Figure 51 – Upper level terrain used on Pegasi Delta

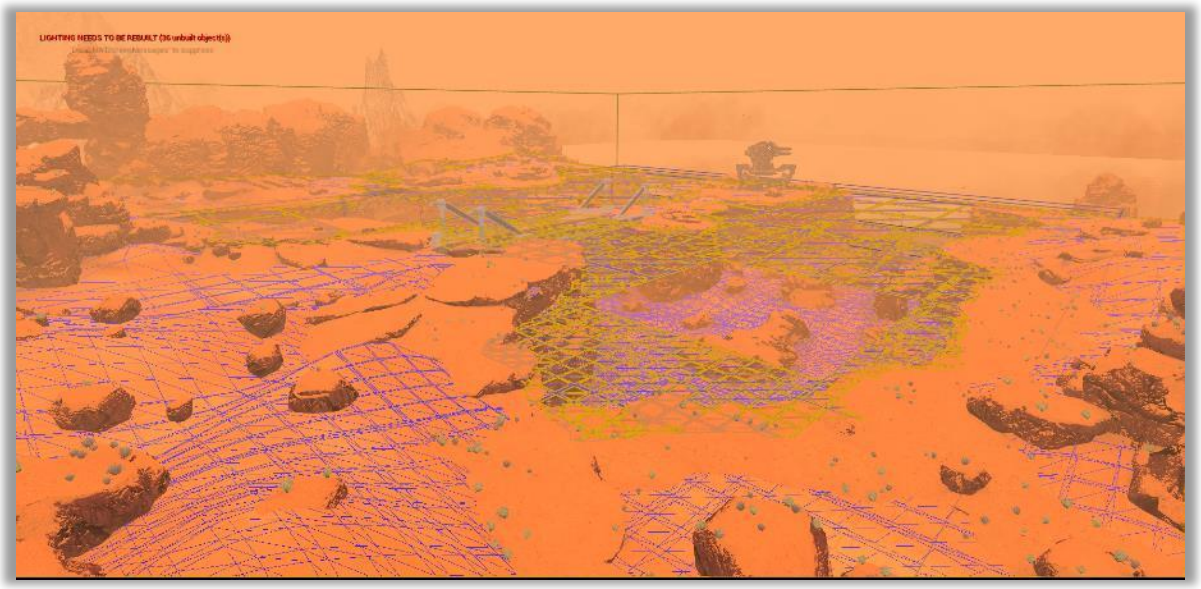

Figure 52 – Upper level terrain used on Pegasi Delta wireframe

3.3.3 Further map development

Undulations were added to the terrain to enhance realism as well as the addition of red rocks, scattered in and around the maps accessible areas. Rocks were placed in an asymmetrical manner and were designed to not only act as cover, but to guide the player along with the sand pathways. An example of this can be seen in figure 54, where the two rock formations act as a ramp for players and therefore attracts players to use it.

Figure 53 – Rock formation used as a vehicular ramp

In the original map design (figure 55), the cliffs opened towards the ocean, which provided a more realistic aesthetic. This created guiding lines that attracted players to potentially leave the map (Ross, B., 2015). It also acted as a doorway, attracting the player to go through it. This was a technique described by Mark Brown (Brown, M., 2015) in his video on creating navigation elements using lights and hidden sign posts.

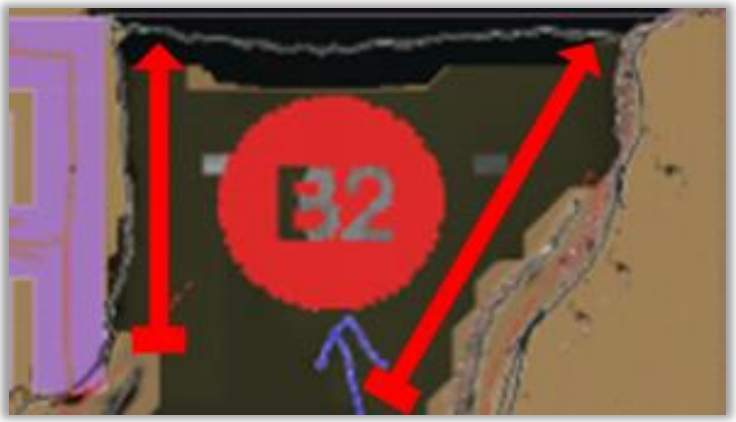

Figure 54 – Pegasi Delta shoreline map sculpt

To reverse this effect the cliffs were re-sculpted to hug the player base's which can be seen in figure 56. The aim of this was to have two effects:

1. To draw the players attention away from the sea opening, thus not encouraging them to go that way through design.

2. For the new cliffs layout to act like subtle directional arrows, influencing players to circle the base as designed (figure 55 & 56).

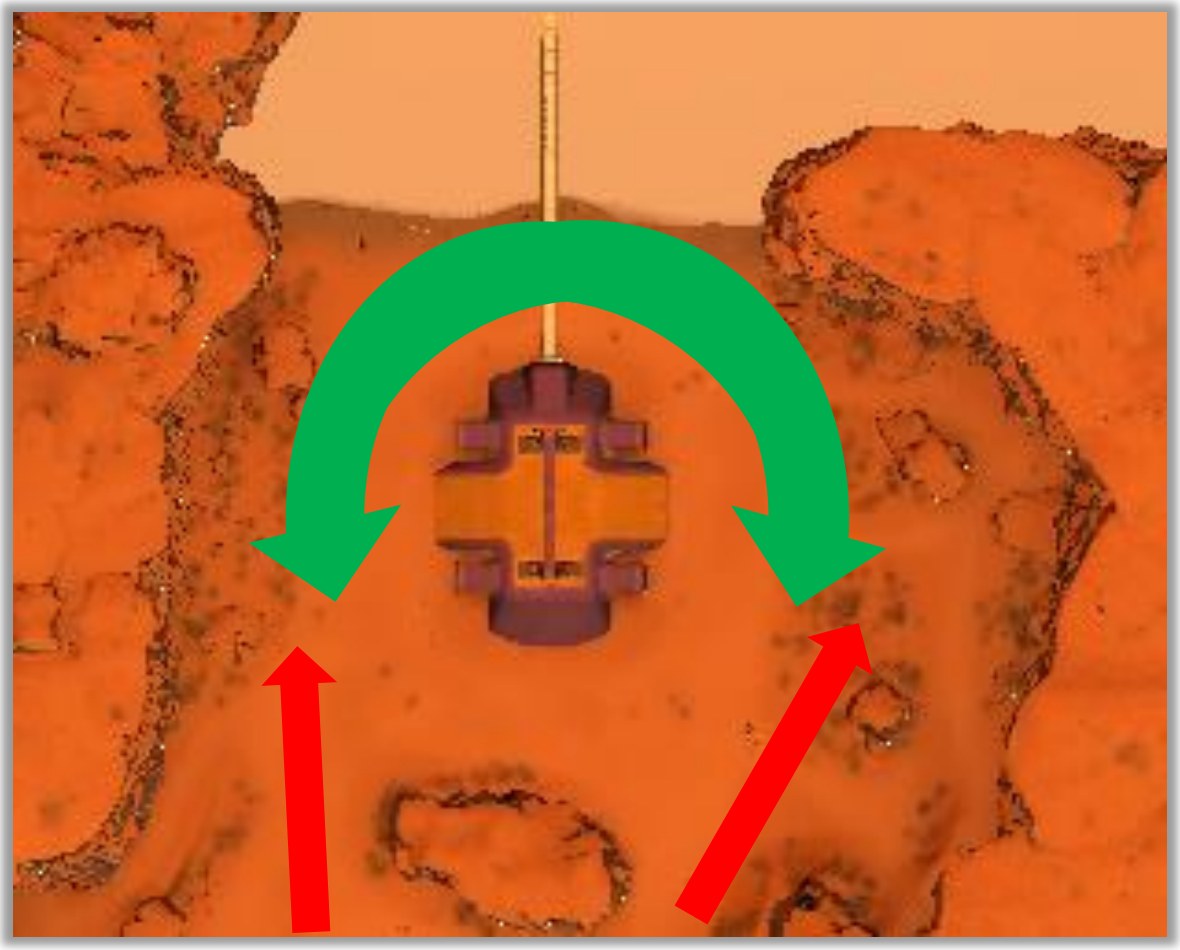

Figure 55 – Re-sculpted cliffs with their intended results Top view

Figure 56 – Re-sculpted cliffs with their intended results

The most substantial changes to the map was made to the UNSC tunnel and the UNSC foot tunnel linking the southern part to the centre of the map. In the original design, the two sides of the level were connected by a single straight tunnel. This area undertook a few revisions.

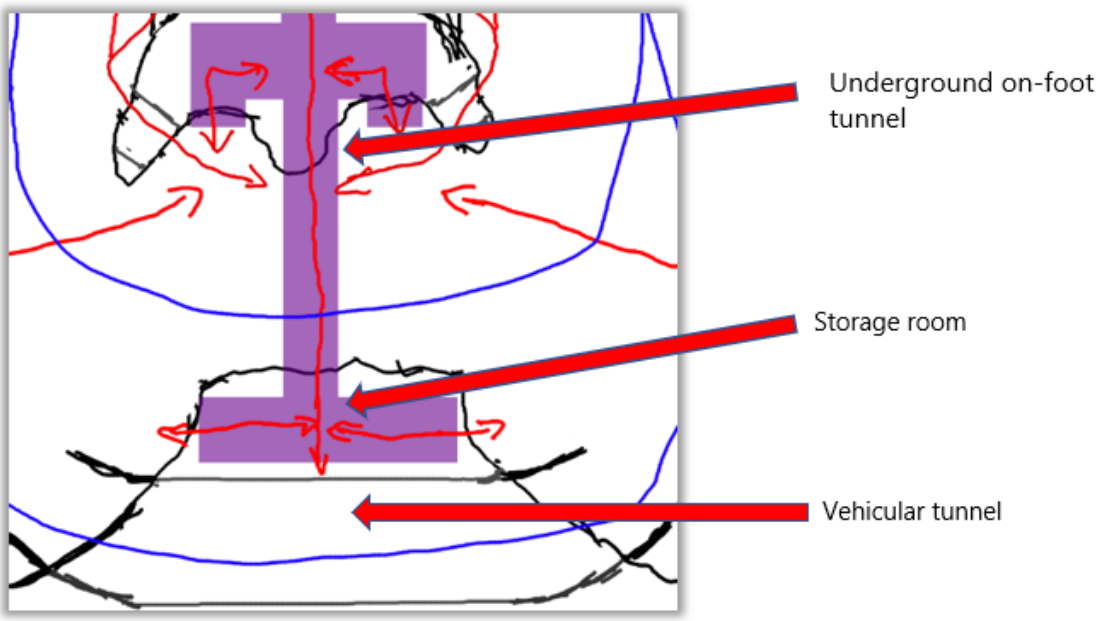

Figure 57 – Map of southern section of Pegasi Delta

The first major revision of this area saw the entrance to the foot tunnel leading from the vehicular tunnel redesigned. Instead of a single small doorway used to enter the storage room, a whole structure was created which was based on designs used in Halo 3's Rats Nest map (figure 58 and 59).

Figure 58 – Second iteration of vehicle tunnel

Figure 59 – Rats Nest map from Halo 3 (Spartan-112b, 2010)

In addition to this, the foot-tunnel leading towards the centre of the map had a deviation added to it to stop long range weapons being too powerful.

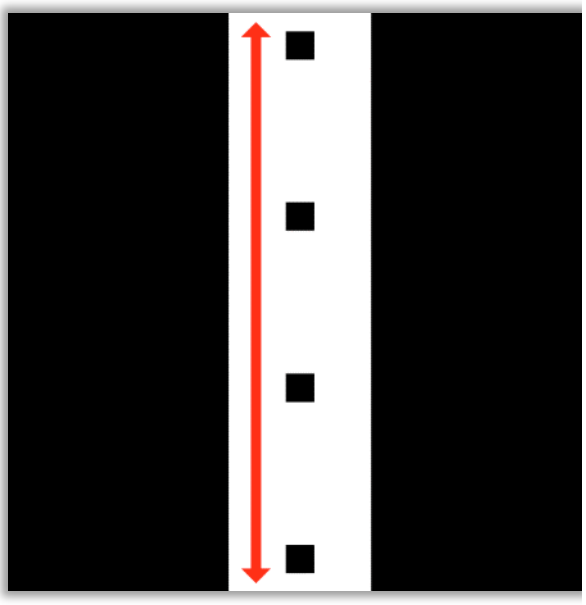

Figure 60 – First iteration of foot-tunnel

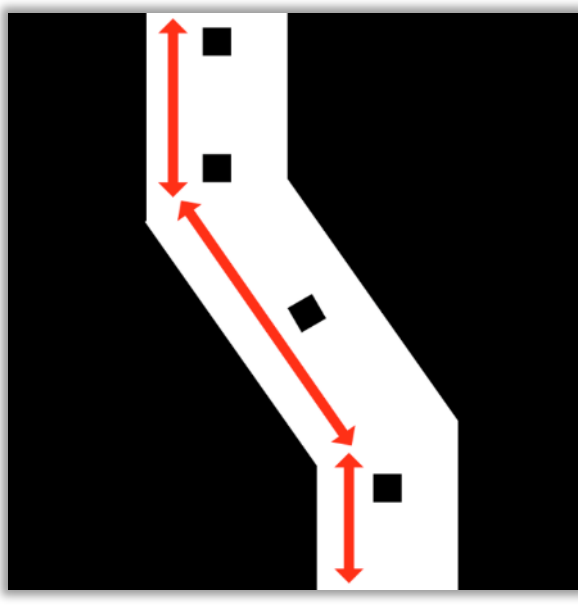

Figure 61– Second iteration of foot-tunnel

Later, the foot tunnel area of the map was removed, and the vehicular tunnel was simplified to two vehicular entrances on either side of the map. This was done as the map had too many combat zones which could dilute players engagements on the map.

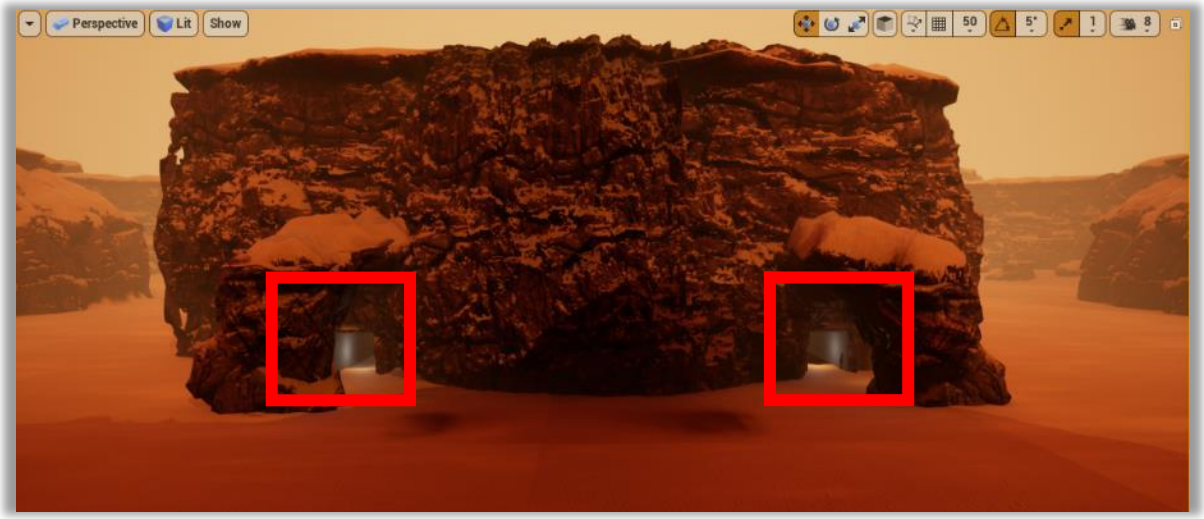

Figure 62 – Original entrances to centre of the map

This meant the centre of the map needed to be redesigned to accommodate this change (figure 62 and 63.

Figure 63 – Revised design for centre of the map

3.4 Final touches

The final stage in the development pipeline was to add the finishing touches to the level. In this stage, Optimisations are implemented, Blueprint scripts written, and Particle effects created.

3.4.1 Optimisations

LOD's (Level of Detail) are used to render 3D models in decreased numbers of polygons. The level of detail used for a model is typically tied to the distance from the viewport. This mean the further away from a model the viewport is, the lower the polygon count of the 3D model. In UE4, LOD's can be created in engine for any model. In addition, LOD's are automatically calculated and applied to landscapes.

Simplygon was used to create LOD's in this project. Simplygon uses its own algorithms to create high quality LOD's. This project used both the Maya and UE4 plugin.

The Simplygon Plugin for UE4 can be used to create Static Mesh LOD's, Skeletal Mesh LOD's, HLOD proxies and Level Streaming LOD's. All of which replace the default UE4 system. For Pegasi Delta, Simplygon's static mesh LOD system was used for the terrain's LOD system. In addition, Simplygon HLOD proxies were used for the map foliage. This system generates computationally cheap representations for mesh clusters, which drastically reduces draw calls.

Many of the meshes created were low polygon, so most didn't need LOD's. However, some static meshes developed by third parties were of a very high polygon count. A good example of this is the SM_Cliffs used to create the cliff sides. Each of these models were at ~30,000 triangles (figure 64). All cliffs on the map accumulated to ~8,000,000+ triangles.

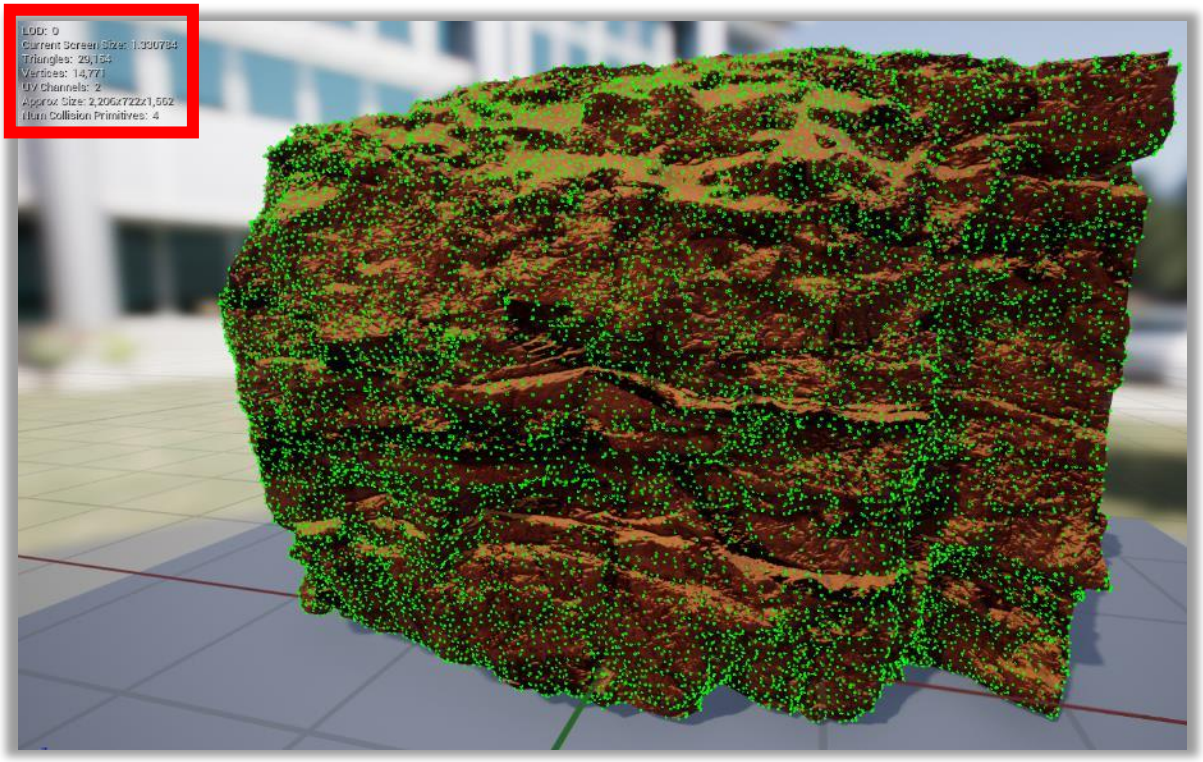

Figure 64 – Original Cliff static mesh (High poly)

This asset was exported into Maya where a new low polygon version (figure 65), along with 3 LOD's was created.

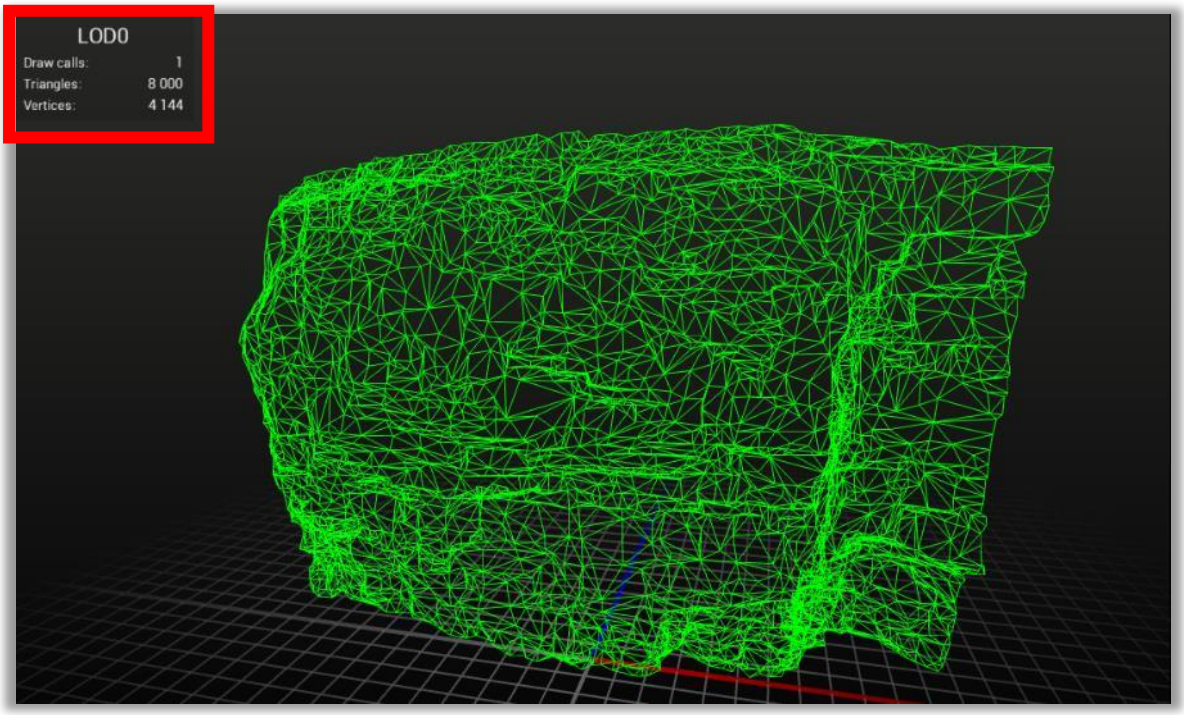

Figure 65 – New low poly cliff mesh

Simplygon offers a simple polygon reduction where the user can easily reduce the number of polygons. LOD's were created using a fully automated LOD pipeline where the user specifies the number of LOD's and how many polygons each LOD should have (figure 66).

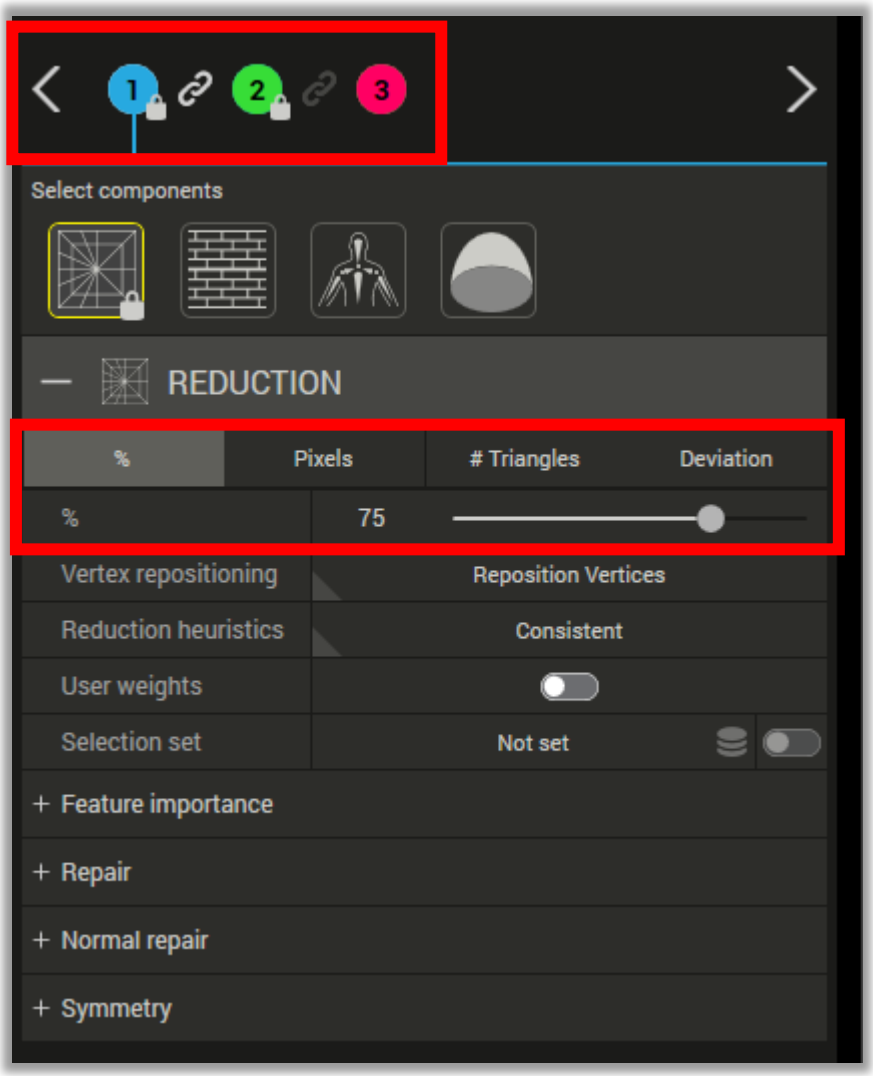

Figure 66 – Option for Simplygon reduction chain

4 models including the three LODs are exported from Simplygon to UE4 via Maya.

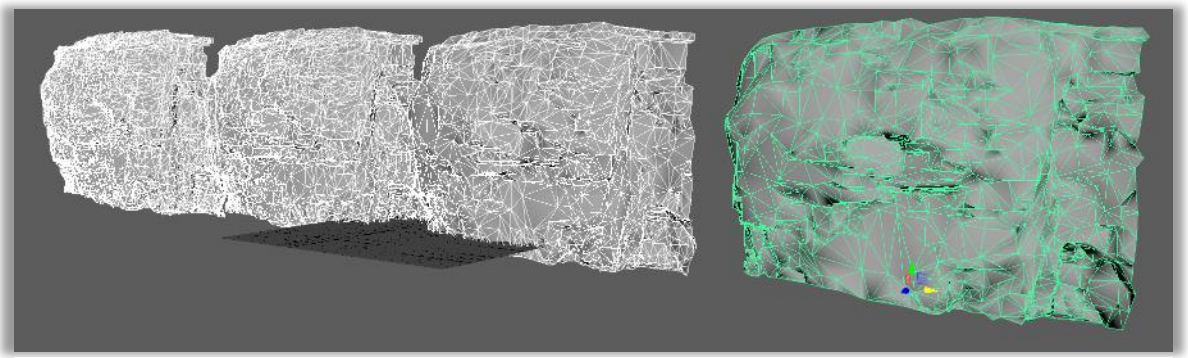

Figure 67 – New cliff mesh with LOD's

These new models replaced the current old high poly models in UE4. All settings for LOD's were set at Simplygon's default for the optimal parameters. The result of this was the lowering of the polygon count from ~8,000,000+ triangles to ~2,000,000 triangles. This technique was also applied to several tertiary rock models and the Covenant Tyrant AA gun.

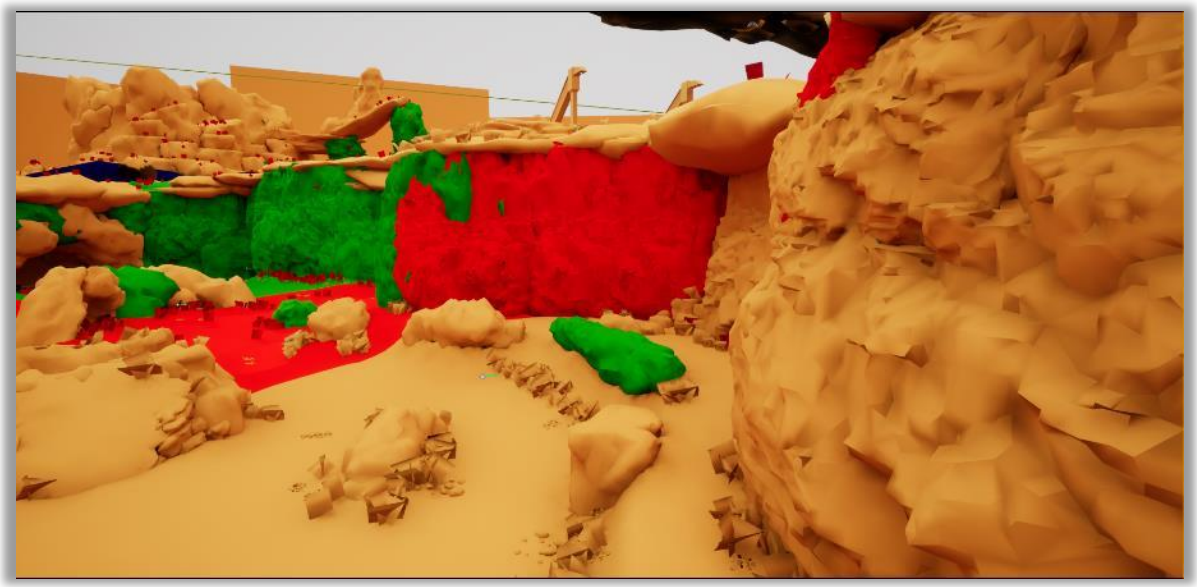

Figure 68 – Cliff LOD's working in UE4

A Lightmass Importance Volume was used to limit the areas where lighting was calculated. This stops meshes outside the playable area from having their lighting calculated, saving computational resources.

3.4.2 Blueprints

Throughout Halo games, players have always been presented with varying means in which to traverse a map. As maps became larger to accommodate vehicular warfare, players on foot would take much longer to reach combat. Two common solutions that were used in Halo were the Teleporter and the Man Cannon.

When researching into Bungies multiplayer map design, Teleporters were often found linking a player base to an area of the map which is inconvenient to access. For Pegasi Delta, the teleport pads were placed in players bases and would link to a structure found on the ridgeline, highlighted on figure 69.

Figure 69 – Teleport locations on Pegasi Delta

UE4's Blueprint visual scripting was used to create the teleporting functions (figure 70). A Volume was placed at each of the teleport locations. When the player collides with the teleport volume, the player would be sent to the second volume. However, once a player had been sent to a second teleporter they were then colliding with this teleporter and were sent back again, looping continuously. Therefore, a delay of 1 second was added after a player teleported preventing any loops.

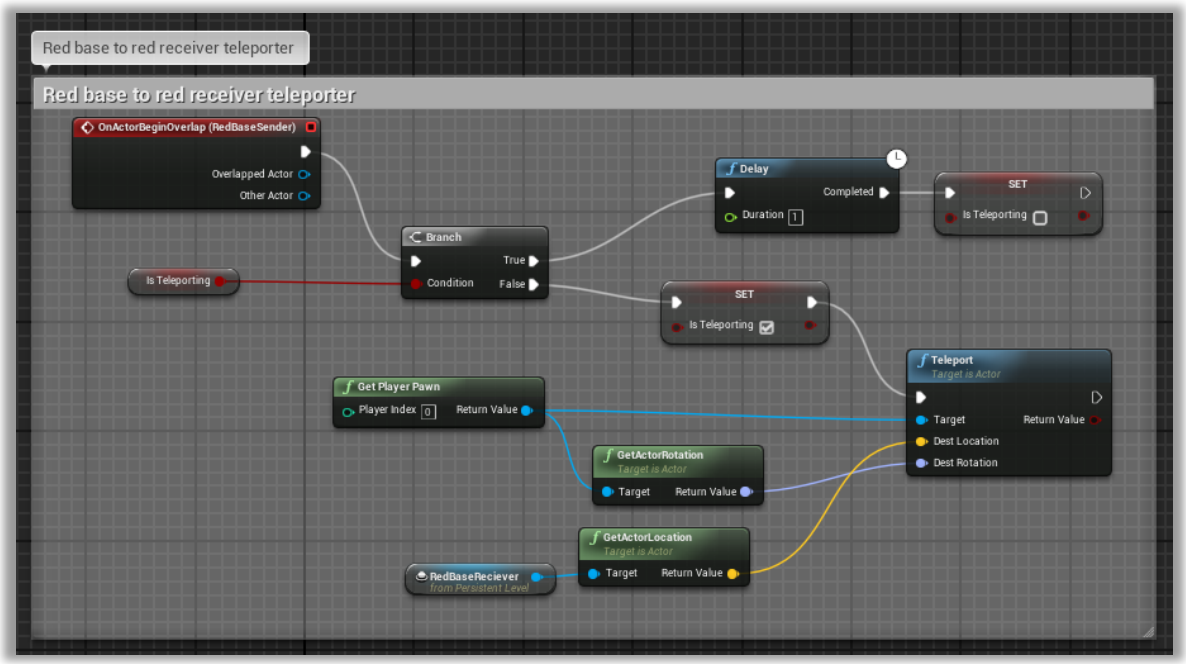

Figure 70 – Teleporter blueprint

When walked onto, Man Cannons send the players flying to another location on the map. Similar to jump pads found in many games.

Figure 71 – Man Cannon on Pegasi Delta

Much like the Teleporters, the Man Cannons operate when an overlap between the Man Cannon and player is made. When true, the Man Cannon casts a vector to the player (figure 72).

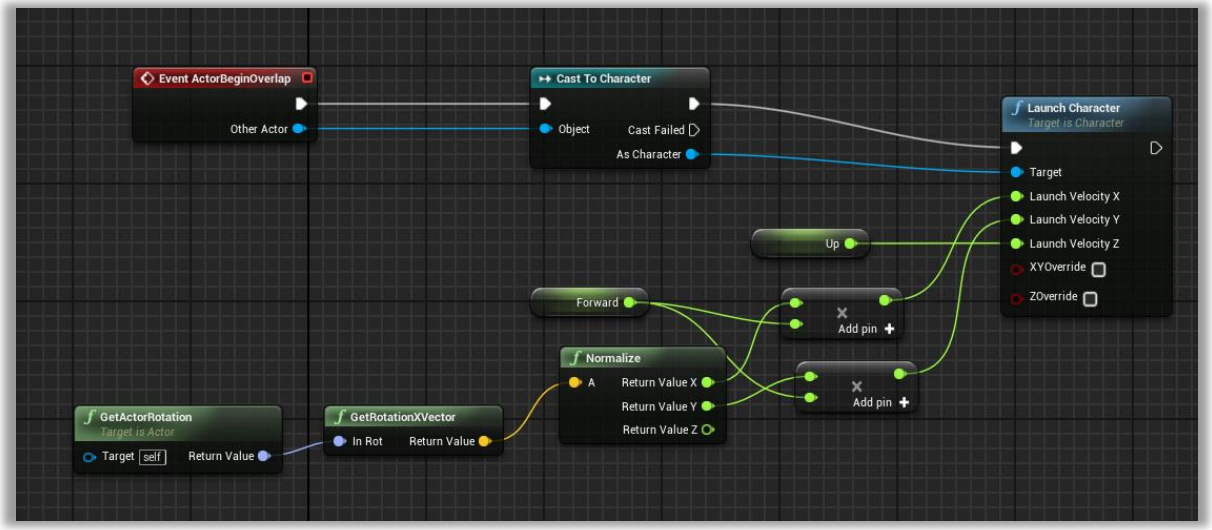

Figure 72 – Man Cannon blueprint

3.4.3 Particles

Man Cannons found in Halo have a blue effect, as seen in figure 73. To recreate this effect, UE4's particle system was used.

Figure 73 – Halo Reach Man Cannon (Shazamikaze, 2013)

Two particle emitters were created and set to be GPU sprites to apply the workload onto the GPU. Both effects are spawned in a cylinder in order to better fit the Man Cannons mesh shape (figure 74).

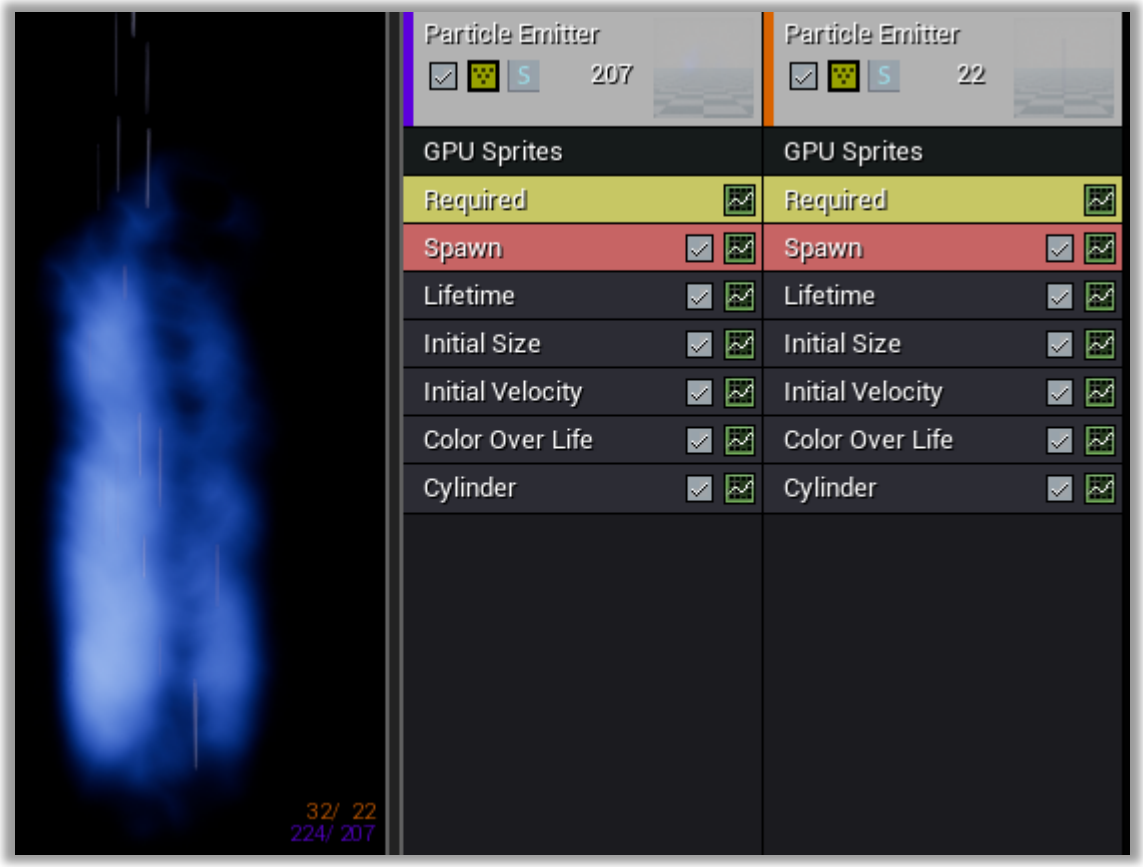

Figure 74 – Pegasi Delta Man Cannon particle effect

A Sand-storm effect was created to make sniping across the map harder for players. This was created using a particle effect in UE (figure 75).

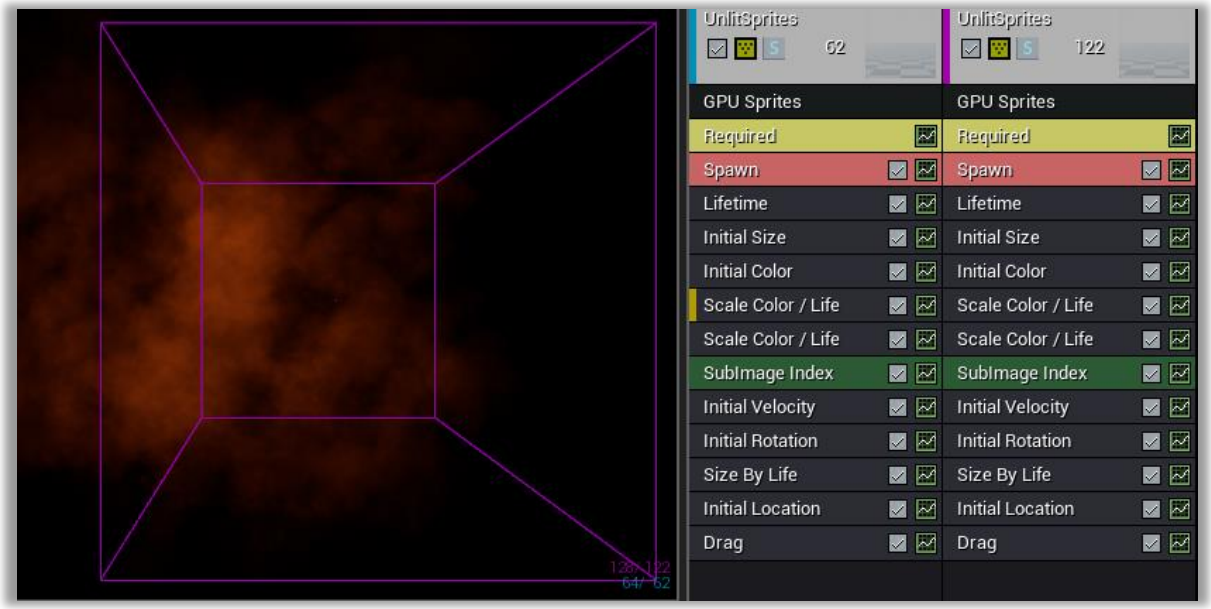

Figure 75 – Pegasi Delta Sandstorm particle effect

Two emitters are used to add variation to the particle. To stop the fog from being visible close to the player, changes were made to the spites material. This was done using a depth fade node which slowly blends in and out the particle effect from view (figure 76).

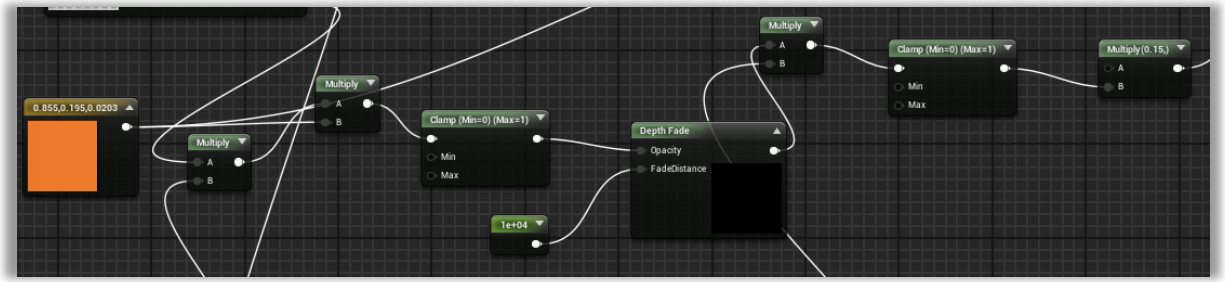

Figure 76 – Pegasi Delta Sandstorm material depth opacity

3.4.4 Lighting

Basic lighting was added to the map through various sources. The exterior of the map was primarily lit through the skylight. This light source was modified to produce a faint yellow light as per the environments description provided in the novel Ghosts of Onyx.

Figure 77 – Interior UNSC light example

For interior lighting, a mix of Spot, Point and emissive lights were used. Spotlights were used to for most interior light sources as it provides the most realistic lighting effects for UNSC (human) lights. Point lights were used to correctly light up shades as highlighted above.

Figure 78 – Interior Covenant lighting example

For Covenant interiors, a mix of emissive and point lights were used. Hallways were lit both using static emissive lights directly from wall pieces, and point lights, which lit up areas without causing the emissive wall lights to produce glare.

3.5 Review of Final Touches stage

Many of the topics discussed in this section were not in the authors opinion polished or to a high enough quality. The purpose of this stage is to get the project to its finished point where if it was a full game, it would be released to the public. However, only one iteration was completed leading to a lack of polish. A good example of this can be seen on the Man Cannon particle effects (figure 79).

Figure 79 – Problem with Man Cannon particle effect

When looking at the effect directly from the front, it was visible that most of the particles spawn on the objects left side.

Optimisation techniques such as Level Streaming weren't implemented in the project due to a lack of time. This is where the level can be broken down into sections so that the engine can load/unload sections to better use memory. A custom version of Level Streaming would need to be implemented for a multiplayer level, as the UE4 system doesn't load sections based in individual player locations, but instead loads based on the location of all players combined (Epic Games, 2017).

3.6 Testing

When developing a Multiplayer level, playtesting is the main method in which to measure a levels success. According to Elisabeth Schwartz (Schwartz, E., 2017), end users should be playtesting a multiplayer level frequently throughout development, as well as testing with other Level Designers, as they have a greater knowledge of what they should be testing (Galuzin, A., 2008).

As this map was designed around Halo, this means without fully implementing these mechanics, it was impossible to provide a fair player testing scenario. This project's scope doesn't cover the implementation of these mechanics.

In this case, achieving the project objectives was the best method to measure the success of the project. Some of these objectives are demonstrated throughout sections 2 and 3.

A questionnaire was created to assess whether the project aim and objectives has been met. This questionnaire helped provide evidence to arguments made by the author and aimed to get quantitative and qualitive data.

The questionnaire was to be distributed to Halo fans as well as Games Technology Students. This would provide data from people who have good subject knowledge when it comes to Halo as well as more technical knowledge regarding Games Design.

The questionnaire was broken into various sections with the starting question being easy to answer with later questions allowing for more open-ended answers.

4 Critical Reflection

In this section, the author reflects on the Pegasi Delta project by evaluating both successful aspects and those which have fallen short. To assist in the reflection, the project aim, objectives and the results of the survey have been used to back up arguments.

4.1 Pegasi Delta vs Bungie Multiplayer maps design

The aim of this project was "to enable the learning and application of professional practice for the level creation pipeline resulting in the development of an original Halo inspired map of equivalent or better". Therefore, the project should have accurately mimicked Halo Level Design through the application of industry standard techniques.

A Level Design document was created during the Planning and Pre-production stage, which contained analysis of Bungie Multiplayer Level Design for maps similar in scale to Pegasi Delta. The analysis demonstrates how three distinct routes are available to players to reach the enemy base. This was recreated in Pegasi Delta with the main routes shown below in figure 80.

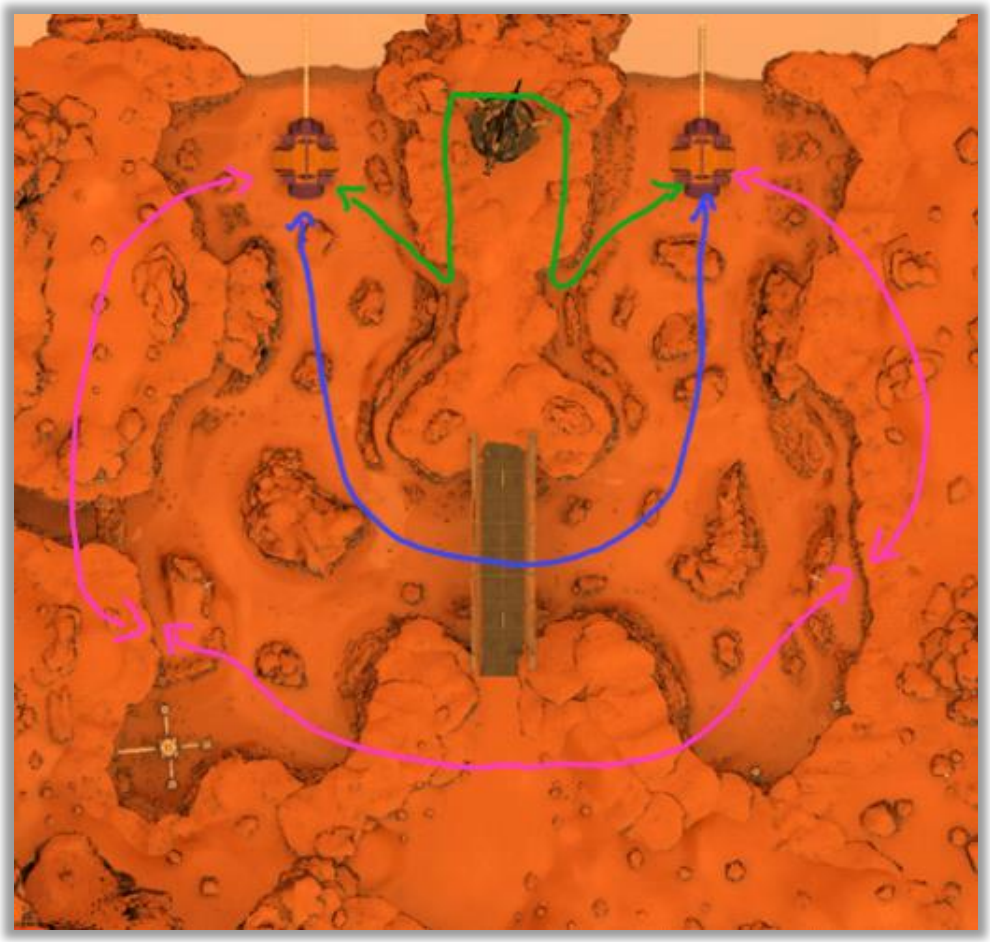

Figure 80 - Three main routes of navigation on Pegasi Delta

Pegasi Delta shared a variety of Halo multiplayer map traits. Many of Bungies maps are set in canyons, which eliminates the need to utilise invisible walls to contain the player. According to games designer Bobby Ross (Ross, B., 2015), this is good Level Design practice. Many of Bungies maps are symmetrical as is Pegasi Delta.

Of participants asked, if "the map is recognisably inspired by Halo" during the survey, 92.3% agreed while only 7.7% slightly disagreed.

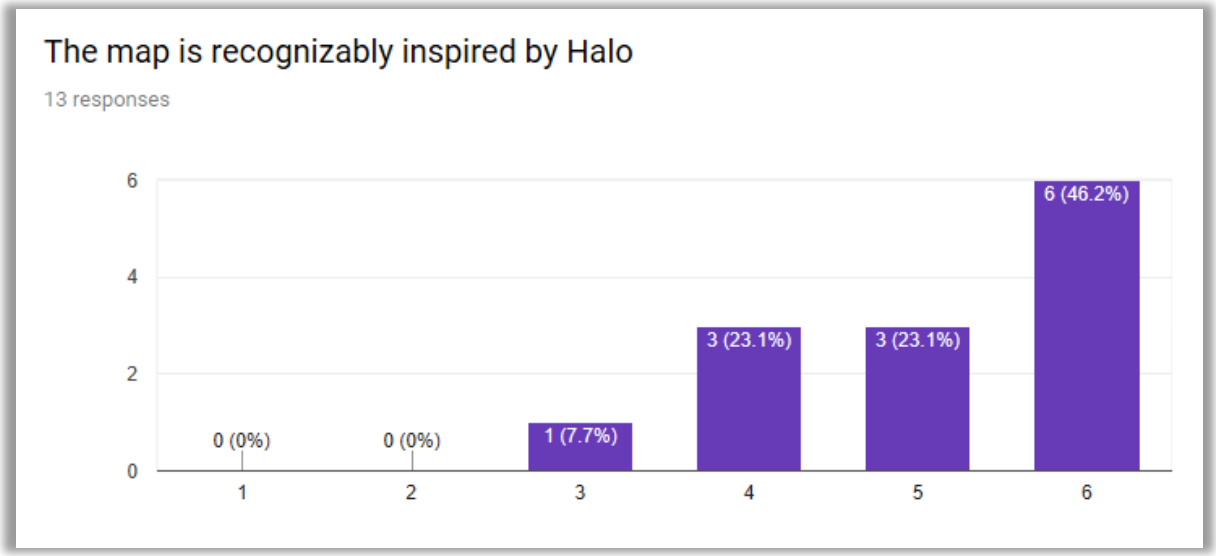

Figure 81 - The map is recognisably inspired by Halo results

While was not possible to classify the disagreement as an anomaly, the participant didn't further expand on why they were of this opinion.

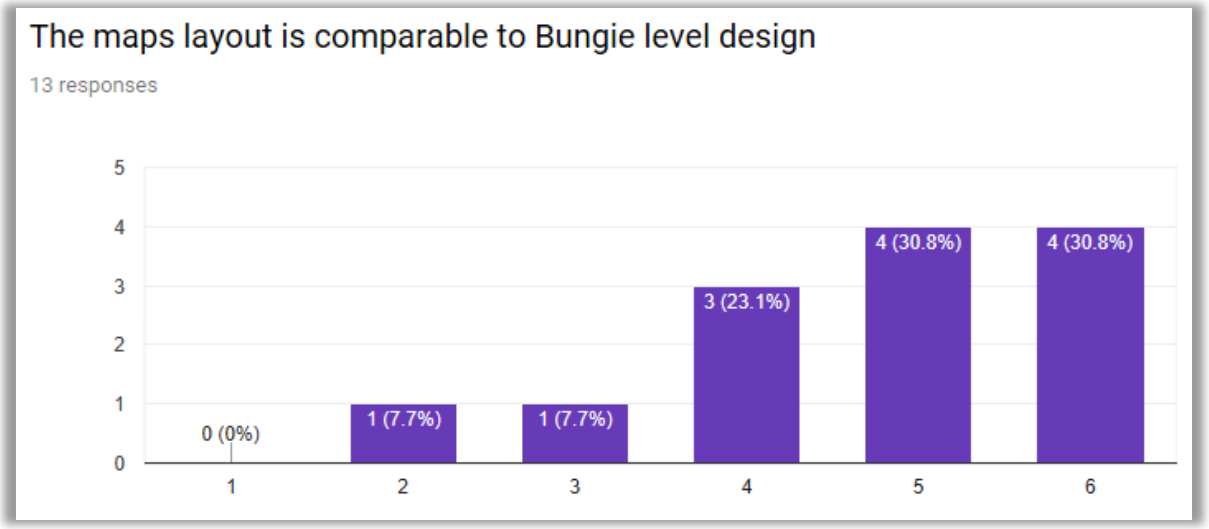

Figure 82 - The maps layout is comparable to Bungies Level Design results

When asked if "the maps layout is comparable to Bungies Level Design", 84.7% agreed while 15.3% disagreed. A participant who described themselves as a fan of the Halo series, provided detailed feedback regarding the similarity to Bungie maps.

> *"The map's overall design is very reminiscent of the maps Sidewinder and Avalanche (horseshoe shape, along with various tunnels cutting through the middle). The bases on either side of the map are, as stated before, the same structures from Snowbound, the general sandy aesthetic reminds me of Sandtrap. The uneven terrain and protruding rocks acting as cover to move through is similar to various halo maps such as Blood Gulch. One other minor similarity is also how three sides of the map end in cliffs while the back of the map ends in some kind of ocean or lake, this is similar to Valhalla. "*

As discussed in chapter 3, the description of Pegasi Delta would be translated into the level. This was carried out successfully, as all participants agreed that the level matched the description from Ghost of Onyx (section 3).

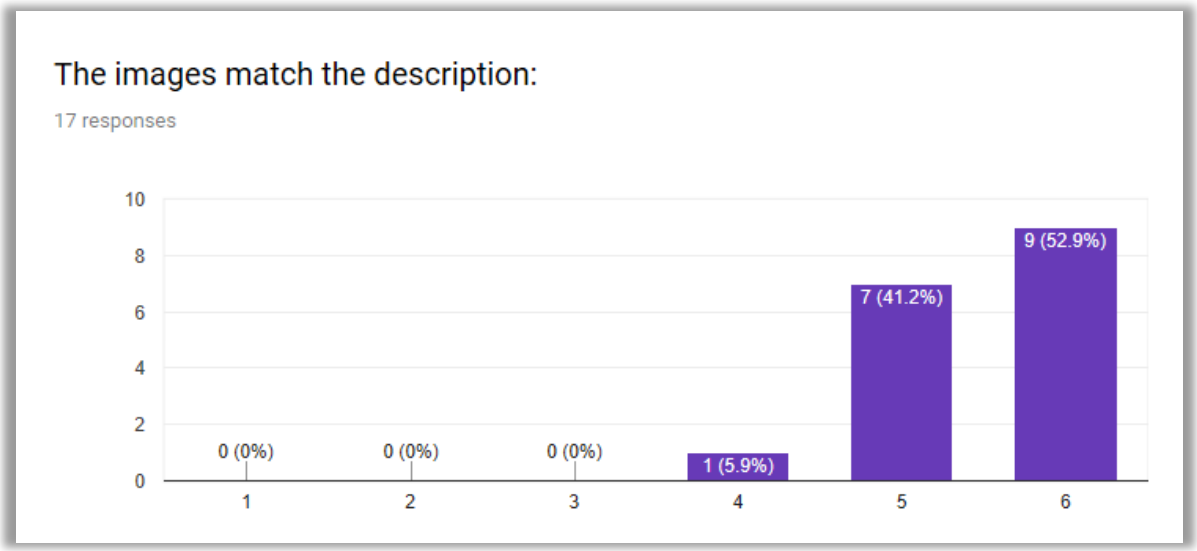

Figure 83 - The images match the description results

5 of the 9 respondents whom elaborated on their answers, stated that the sea didn't match the "unusually green" description from the novel. After some research, it was found that Bungie's version of the same liquid (figure 84) did closely match what had been created for Pegasi Delta (figure 85).

Figure 84 - Bungies Heavy Water material from Halo 3 (Phaztic, 2010)

Figure 85 - Heavy Water material from Pegasi Delta

However, 343 whom succeeded Bungie, had a different interpretation of the colour. Whilst the Project and Bungie's liquid was a dull green, 343 Industries had opted for a brighter and emissive green material as seen in figure 86.

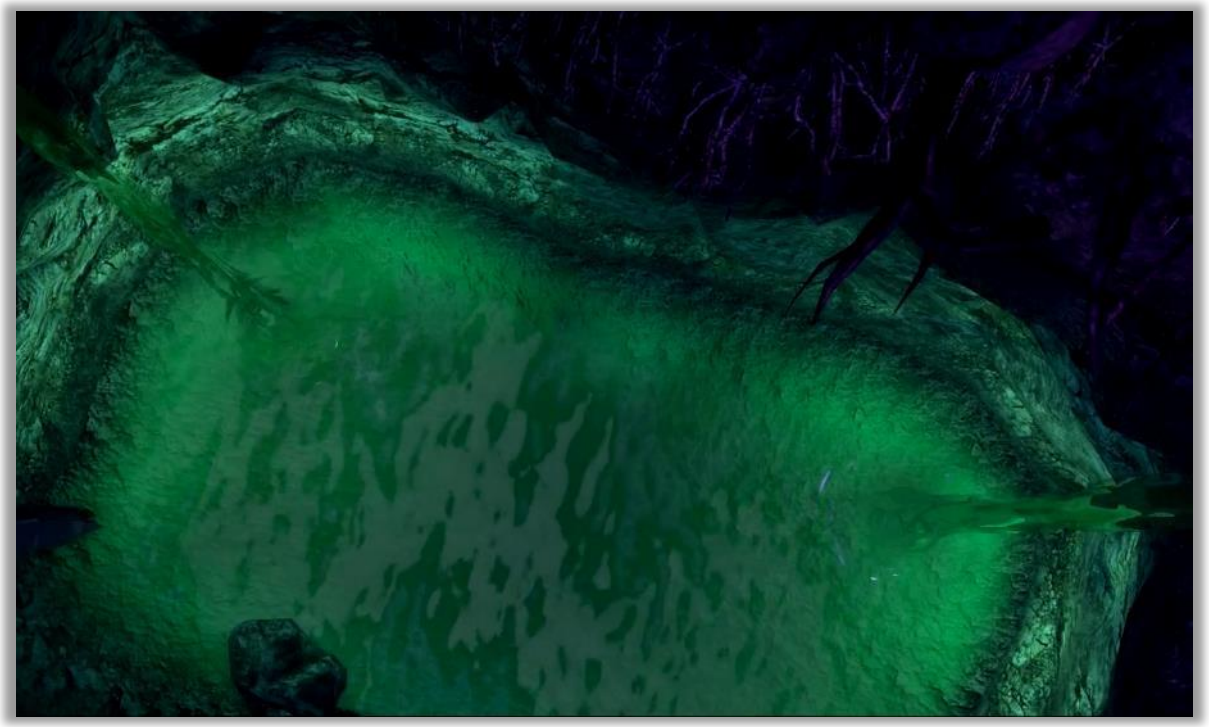

Figure 86 - 343 Industries Heavy Water material from Halo CE anniversary

4.2 Professional practices

As discussed in chapter 2, map structure was very important to a multiplayer map. This includes design considerations such as fixing exploits, having clear player paths and retaining some underlying narrative to the level.

The fixing of exploits was undertaken throughout development. This included fixing the foot tunnel storage room by altering asset placement, as well as the addition of a bridge, sandstorm effect and re-sculpting of the cliffside to stop cross map shooting from the outer ridge lines. While these considerations have been made, it wasn't possible to state this requirement has been met fully without thorough gameplay testing. This issue also applies to the testing of clear player paths. It's unknown whether these work as intended without gameplay testing.

Having a strong and unique theme was recommended by Scott Rogers (Rogers, S., 2014) and Bobby Ross (Ross, B., 2015) to "make the map memorable" and to help provide an identity to the map. Pegasi Delta uniquely incorporated two different architecture types (Figure 87) which relates to the description of the environment in Ghosts of Onyx.

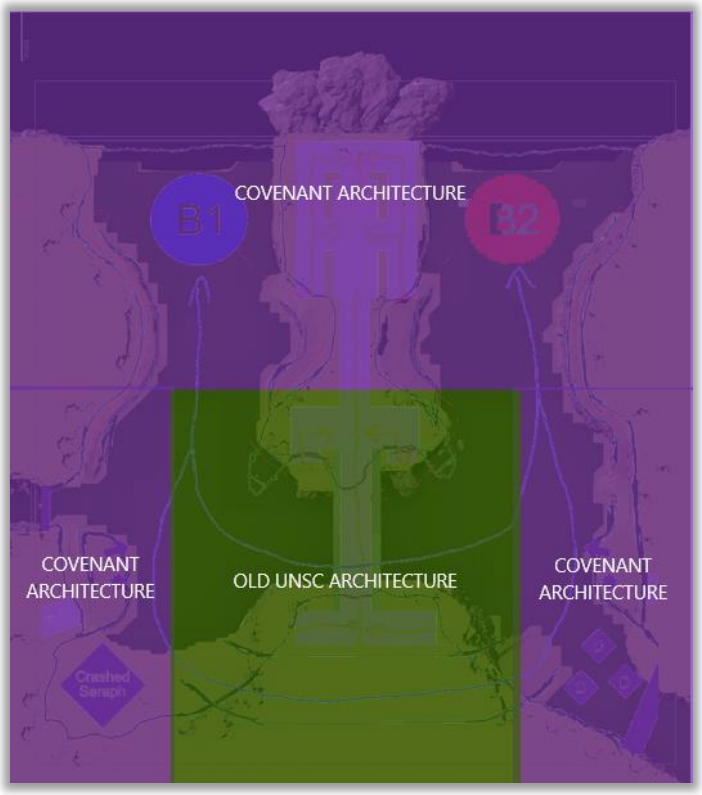

Figure 87 - Pegasi Delta's architectural balance

To test this theme, the question, 'Looking at the maps architecture, what would you describe it as being primarily?' was proposed to participants.

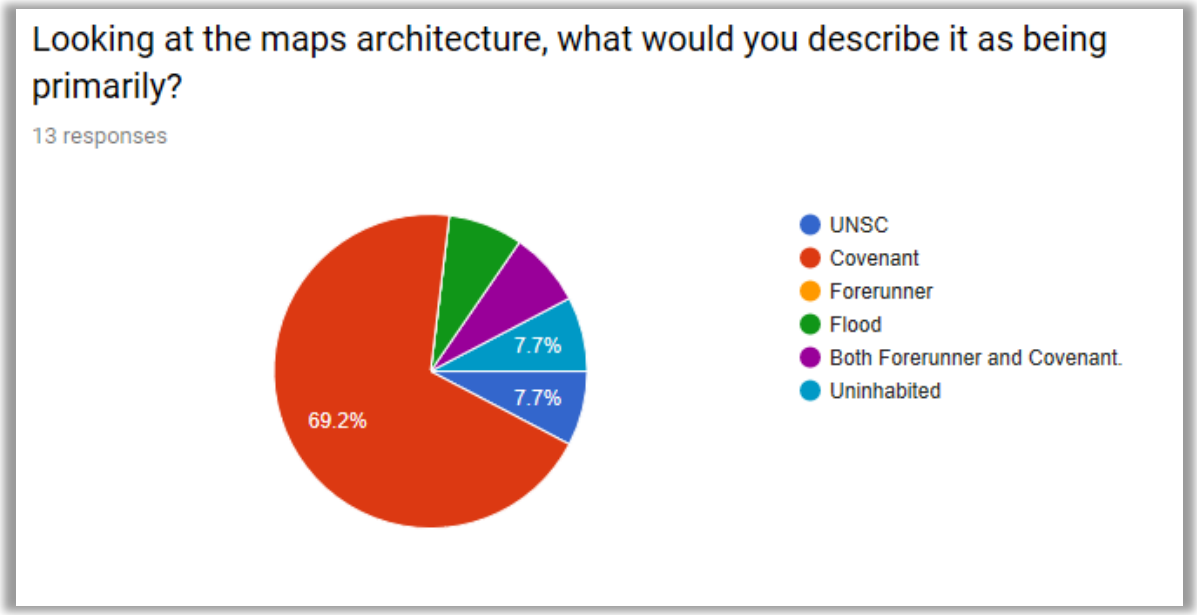

Figure 88 - Looking at the maps architecture, what would you describe it as being primarily results

Most respondents correctly identified that the maps primary theme was Covenant Architecture. The respondent who replied with the answer of 'Flood' should be disregarded as the respondent requested to change their answer to Covenant after they submitted. When asked to provide further reasoning as to why respondents answered the question the way they did, one wrote:

> *"It would appear to be a human colony that has been under attack/ survey by the covenant, with the bridge and underground bunker being of human construction."*

This closely matches the narrative that the level intended to covey to players.

The project researched and applied techniques that were used in the Level Design pipeline. These were researched in chapter 2 and include 'Continuous Iteration' and 'Photogrammetry'. While many of these techniques weren't applied, more suitable techniques replaced them based on research conducted. Many of the techniques applied during the development of the project are used in the Games Industry. These include PBR texturing, LOD creation and Guiding lines in Level Design. In terms of advanced lighting techniques, these were not researched and applied due to a limited time constraint.

On reflection, it can be argued that with 5 out of 6 project objectives completed (Advanced Lighting techniques weren't achieved), and positive feedback received from the questionnaire, this project was a success as the project aim was achieved.

5 Project Conclusion

5.1 Project reflection

5.1.1 Positive outcomes

To conclude, the project had many positive outcomes. Many skills acquired at University have been built upon and applied during this project. Many of these are new, especially in term of the Pre-Production of a game level. It has taught the author to think practically about Level Design in terms of its flow, balance and pacing etc…, then compared to previous Level Design projects. The project has taught the author practical skills such as Landscaping, Complex Materials in UE4 and Particles.

5.1.2 Improvements for the future

Whilst there have been positive elements of the project, much improvement could be made. One objective not met, due to the limited time scale was to identify and apply advanced lighting techniques. This was not achieved due to the limited time scale, consequently, only basic lighting was implemented. In addition to this, assets could have been created to a greater fidelity and Level Streaming could have also been added throughout development to improve optimisation.

5.1.3 Future work

The projects current state provides a great foundation to further improve the projects implementation. Advanced lighting, improved models and better optimisation would be incorporated. It would be worthwhile carrying out a multiplayer play test of the project once Halo-like mechanics, better optimisation and noteworthy bugs such as the man cannons logic for its fire direction has been fixed. This would allow for better data in terms of map balance and playability.

5.1.4 Future projects

Many lessons have been learned from the undertaking of this project and will be applied to any future endeavours. A future Level Design project will not be undertaken soon. Instead, focus has been shifted towards iterating upon this project. This would be done until the level was industry quality and the level could be implemented successfully into a game.

5.2 Final words

This project has shown that the execution of a level inspired by Halo is possible. However, time constraints impeded the quality of what was created. In addition, there was lack of detailed literature discussing Multiplayer map design, making practices and theories of the topic hard to research. This differed greatly to Single Player Level Design as many of practices used weren't applicable to Multiplayer. Undertaking unfamiliar elements of the Level Design pipeline such as concept art, caused

slow progression in the early stages of development. Ultimately, this lead to the project not being industry quality.

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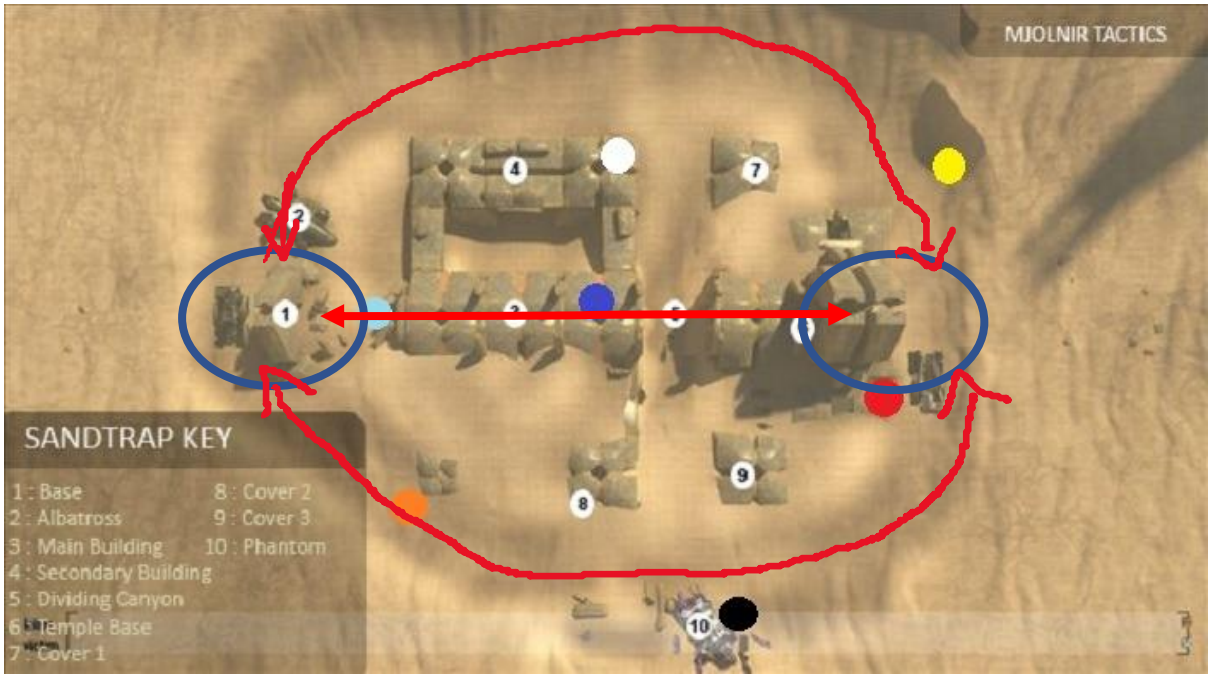
Appendix

Appendices A: Level Design Document

Research into Level Design patterns used by Bungie

From my preliminary research, a few design traits from Bungies larger multiplayer maps are made clear. My first observation is that the larger Halo maps designed by Bungie are often set in canyons. A main reason for this is so that the player can be contained in a set game space which the player can play. By using canyons, it removes the need for invisible walls or soft boundaries. This is something that is to be avoided in games as players will know the limits without needed to be told. On the other hand, the map Sandtrap isnt set in a Canyon. To stop players leaving the game area. Bungie use a soft kill zone by adding mines outside the playable area. This means when players try and leave the map they will be killed. This isn't as good design in terms of design as a canyon when conveying boundaries to players but add a unique twist to the map.

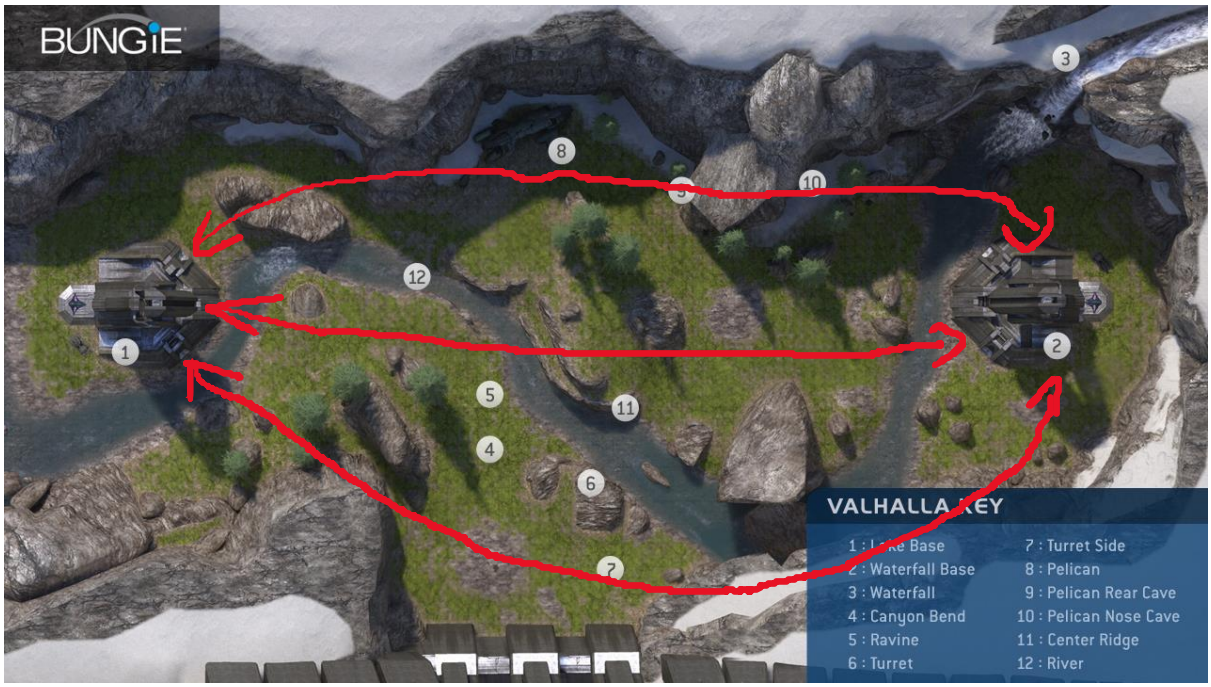
SANDTRAP:



Sandtrap is a large multiplayer map from Halo 3. This map is unusual compared to other large Halo maps as the map shares very little symmetry between the two player starting points (circled in blue). However, the is no noticeable deficit to tactical advantage to wither side. As aforementioned, it is one of a few larger Halo maps which isn't set in a canyon. Another unusual trait is that the map offers two moving bases known as Elephants. Capture points and flags for each team spawn on their respective Elephants. This provides a unique tactical twist. For example, the team can move their elephant towards the enemies in order to allow for quick captures of their flags. This in turn leaves your Elephant venerable for attack. However, if one team is dominating the other, this can lead to a further imbalance for the losing team. This is known as a positive feedback loop (the rich get richer). However, no other Halo level has repeated this mechanic before or after this map.

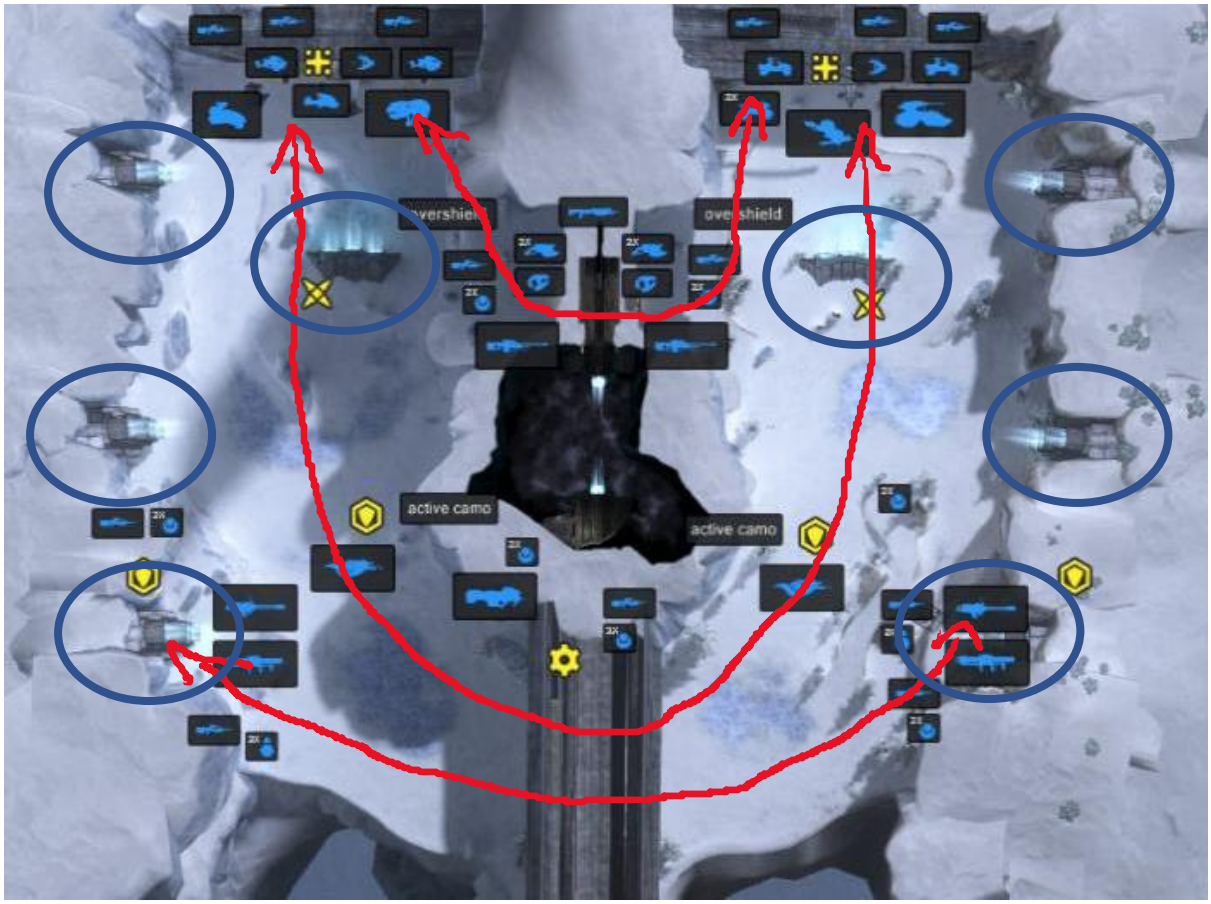
This map offers 3 main attack positions either through the middle or the two flanks. The middle is mainly designed for infantry attack and is the shortest route to the enemy base. However, it is possible for a few smaller vehicles to use this central tunnel system. The two flanks are far more exposed and are design mainly for larger vehicles.

Valhalla



Valhalla is a large multiplayer map from Halo 3. It's widely believed that the design is based off the classic and most iconic Halo map, Blood Gulch. The map is Asymmetrical in its design and inn addition, provides many easy ways for players to navigate. For example, the river flows between both bases meaning navigating to a place of combat or interest is easy for new players. It also makes use of weenies. For example, the crashed Pelican (8) and turret/wall (7) help identify what side of the map the player is on. The map was very well balanced as well, meaning no team would have an advantage over the other. These reasons may be why this map is so popular.

Avalanche



Avalanche is a large Halo 3 map based off the Halo CE map Sidewinder. This maps structure is another common design used throughout Halo games through the Bungie era. This map has three main attack directions with the middle option being design for vehicles. The top path allows for infantry to attack each other without having to follow the full horse shoe structure of the map. The southernmost path leads to the player bases through teleporters. To reach these teleporters, infantry must risk traversing through the open area of the map whilst being subject to enemy vehicles and fixed-point turret. However, the teleporter will drop a player straight into the enemy base, giving a third arm of attack.

Another interesting addition to the map is the use of man cannons (circled in blue) which throws vehicles and players across the map. They typically lower the amount of time a player is exposed in the open and decrease the time for players to reach a destination. However, all of the man cannons in this map move the player to an exposed point of the map. This is a risk/reward calculation used to add jeopardy and add variation to gameplay.

Blood Gulch

Possibly the most Iconic multiplayer level throughout the Halo series, Blood Gulch is a large map which has featured in 3 of 4 Halo games made by Bungie and has inspired the creation of many more. Set in a closed Canyon, this map used asymmetry for balance and neither side had an advantage over the other. This map had some issues with gameplay due to its lack of cover between bases. The terrain in this map lacked variation in depth meaning crossing from one side of the map to another usually ended in in the player dying very quickly. This mean many players would just remain stationary in there base resulting in a stalemate and no progression in gameplay. In the Halo 2 (Coagulation) and Halo Reach (Hemorrhage) variants of this map, this issue was addressed by adding greater deviations in the depth of the terrain. The map used a teleporter in each base which would teleport a player towards the centre of the map. The map also offered side routes to the enemy base, however, the routes often were well within range of the enemy's base. This meant flanking and sneaking towards the enemy's base was tricky.

Story /Theme

High level Description

Pegasi Delta is a small world in the 51 Pegasi system, and a natural satellite of the planet 51 Pegasi B. The surface of the world was made of red rocks and sand. Orange dust permeated the sky and had a faint yellow sun, 85 Pegasi-194A. It had seas that were unusually green and rich in Deuterium and Tritium, which the Covenant used in their plasma reactors, and it was used to refuel their ships.

Detailed Description

During the Human-Covenant war, the Covenant forces constructed a massive refinery on Pegasi Delta. With its close proximity to UNSC space, Pegasi Delta became a massive forward resupply and refuelling line for the Covenant ships making incursions in UNSC space.

The UNSC tried many times to neutralize the refinery, including using nuclear weapons launched from slipspace. However, the plutonium linings of the weapons let off an aura of Cherenkov radiation upon reentering normal space, which therefore made their stealth coatings useless. The Covenant easily found and destroyed them. Similarly, there were too many Covenant ships near the planet's moon to send a slow, distantly-launched weapon, a regular invasion force or even Orbital Drop Shock Troopers.

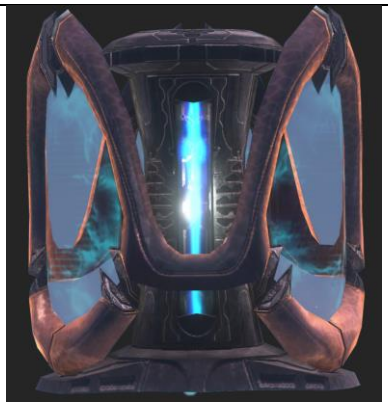
In 2545, the UNSC sent in SPARTAN-III super-soldiers from Beta Company to destroy the refinery in Operation: TORPEDO. They successfully destroyed the refinery by overloading and destroying the reactor causing a massive explosion, crippling the Covenant supply lines, but came out with the apparent death of 298 out of the 300 SPARTANs of Beta Company. The explosion also destroyed seven covenant cruisers that were docked at the factory. Because of this, Lucy-B091, one of the two surviving SPARTANs, (the other being Tom-B292) was so traumatized from the incident that she lost her ability to speak; she was later diagnosed with Post-Traumatic Vocal Disarticulation.

Other Details:

- 85 Pegasi-914A is a star 40.5 light years away from Sol, in the 51 Pegasi system in Covenant territory, well outside of UNSC space. It is visible from Pegasi Delta, described as "faint yellow."
- In 2545, SPARTAN-III Beta Company were dropped into this area as part of Operation: TORPEDO. They were tasked with destroying a Covenant processing plant used for extracting Deuterium and Tritium found in the oceans of Pegasi Delta. This area is known to be a high priority target to the UNSC and ONI.

Technical specifications

Initial Asset List

Asset Name	Description	Reference
Player bases		
Crashed Seraph	Will be used as a Weenie on one side of the map.	
Plasma Battery	Scattered around map with Communication nodes	
Covenant Communication node	Scattered around map with Plasma battery	
Small Covenant Silo	Placed inside team bases	

Covenant Shield Door		
Type 38 Anti Aircraft Cannon	Will be situated on top of the canyon between the two bases. Not accessible to players	
Templar-class Corvette	Weill be placed in the sky as an asset of interest.	

Covenant Automated plasma turret	Used to kill players the leave the map	

Recommended player size

6 – 16: Standard size for Halo's largest multiplayer maps.

Game type's supported

Game Mode	Variants Supported	Description
Capture the Flag	• Multiflag • 1 Flag	here are two teams based on opposite ends of the map. There are also two flags; each one in the corresponding bases (or there can be only one if the game is "attack and defend, or Neutral Flag, like in *Halo 2*). The object of the game is to capture the opponents' flag three times to win, while protecting your own flag from enemies at the same time. Unlike slayer games, total number of kills does not count toward the score. For example, a team who captures the flag three times, but gets no kills, still wins the game. To score, the player with the flag must run directly over their own flag spawn location.
Assault	• Multi-bomb • Single bomb	The player must carry the bomb from their base into a designated arm site, a ring on the floor usually located in the enemy's base, and arm it is by holding it there for a predetermined amount of time. This

		process can be aided by an option called Sticky Arming where arm time can be passed on to other players if one dies attempt to arm it.
Big team slayer	• Team Snipers • Shotty Snipers	Big Team Slayer, players start out with a Battle Rifle and an Assault Rifle as a secondary. First team to get 100 kills wins. Teams comprise of between 5 – 8 players.
Team King of the hill		The aim is for a team to hold the hill for the longest time or to the time requirement. Depending on if the game has a moving hill, you may need to search for the hill periodically.

Supported vehicles list

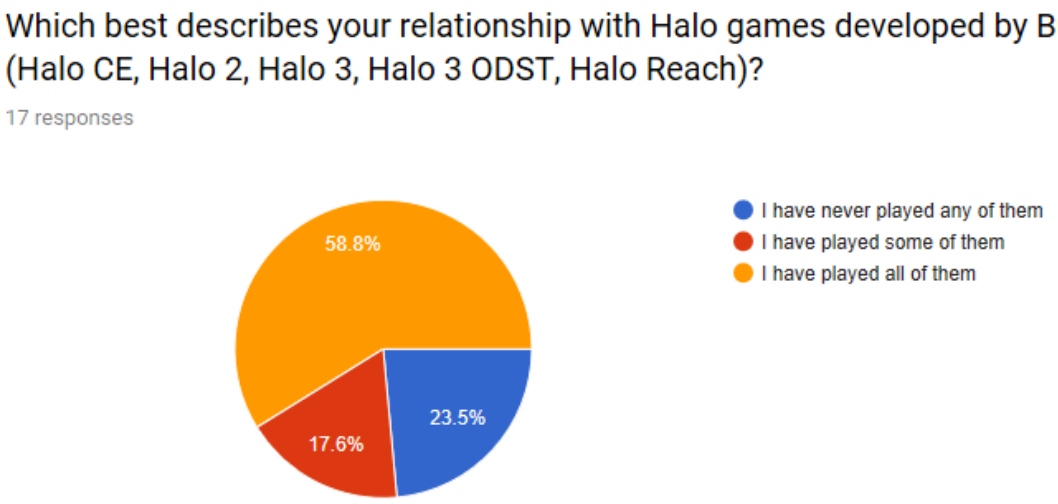
Name	Quantity per team	Reference
Ghost	2	
Banshee	1	
Wraith	1	
Prowler	1	

Appendices B: Questionnaire

For further feedback provided by the respondents, 3 respondents (participant, 2, 8, 16) will be used out of the potential 17. These participants were chosen as they provided the most elaboration to answers. Participants were provided with an array of ~25 images of the level to help them answer the questions.

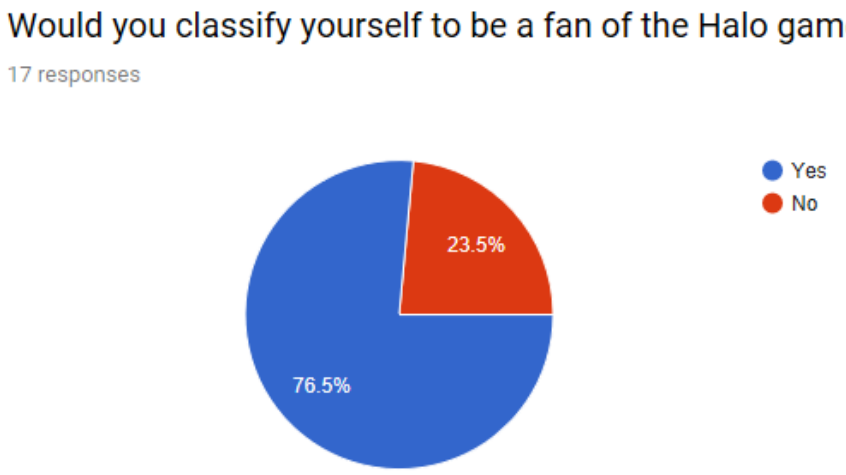
Section 1: Halo Experience

Question 1:



	Participant 16	Participant 8	Participant 2
Answer to question	I have played them all	I have played them all	I have played them all

Question 2:



	Participant 16	Participant 8	Participant 2
Answer to question	Yes	Yes	Yes

Section 2: Pegasi Delta level

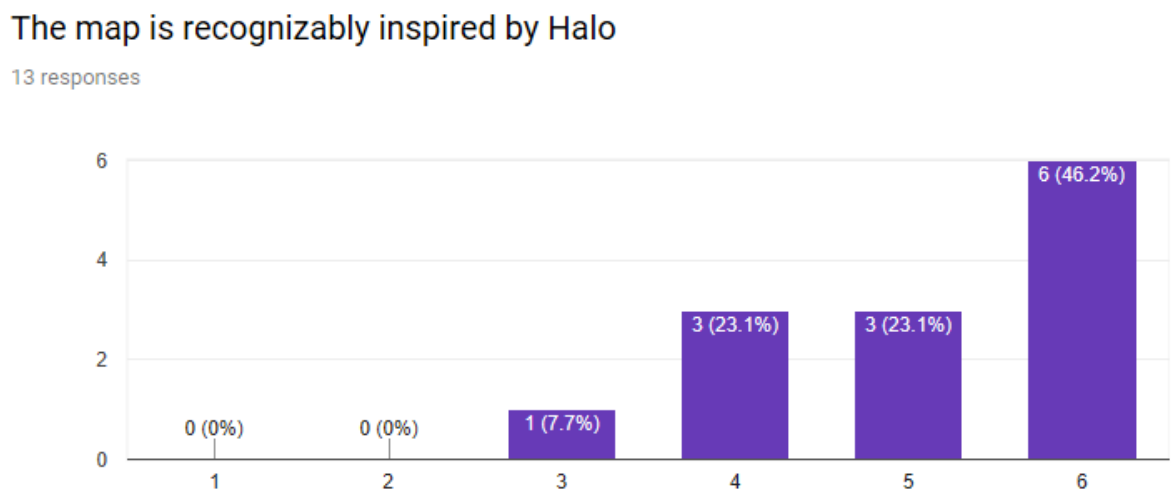
Question 3:

In this section, carefully use the images provided below to answer the following questions.

https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUlFyJtojta?dl=0

Be sure to look at all images before answering the questions.

Please read the following statements and answer on a scale of 1 – 6 where 1 is completely disagree and 6 is completely agree:



Please Explain:

	Participant 16	Participant 8	Participant 2
Answer to question	6	6	5
Explanation	Many of the objects and textures with in the map are noticeably similar to that found within the Halo series (e.g. the anti-air covenant gun on top of the hill, and the ammo/ weapon creates scattered throughout the map).	Recognizable Covenant structures from the series, such as the honeycomb-esque buildings from Snowbound (a Halo 3 multiplayer map), the Tyrant Anti-Air gun from Halo Reach, found can be found on e.g. Outpost (firefight map), and the massive CAS-class assault carrier looming	Even though this is a good attempt at creating a Halo inspired level which is only mentioned by fans and in the books, to me there is still a few things slightly off from it which would make it a full halo level. The lighting is off slightly, the structures seem a bit off with the materials, some of the

		above the map. Other areas, while different, were reminiscent of other halo maps. For example, the area in screenshot 22 reminds me of the Halo 1 map Damnation, and the out-of-boundary turrets are similar to the ones from the Snowbound.	environment looks as if it is missing some of the covenant props that you would normally find in their locations. A few barricades / crates have been added but I feel it's not quite enough.

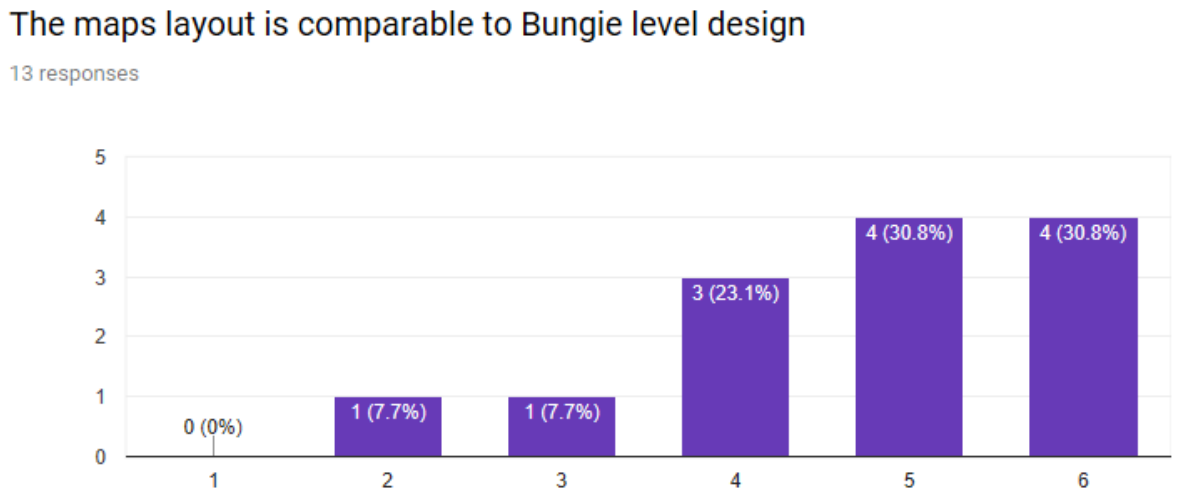
Question 4:

In this section, carefully use the images provided below to answer the following questions.

https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0

Be sure to look at all images before answering the questions.

Please read the following statements and answer on a scale of 1 – 6 where 1 is completely disagree and 6 is completely agree:



Please explain:

	Participant 16	Participant 8	Participant 2
Answer to question	5	6	6
Explanation	The inclusion of two bases of the same	The map's overall design is very reminiscent of the	Bungie have been known in keeping their

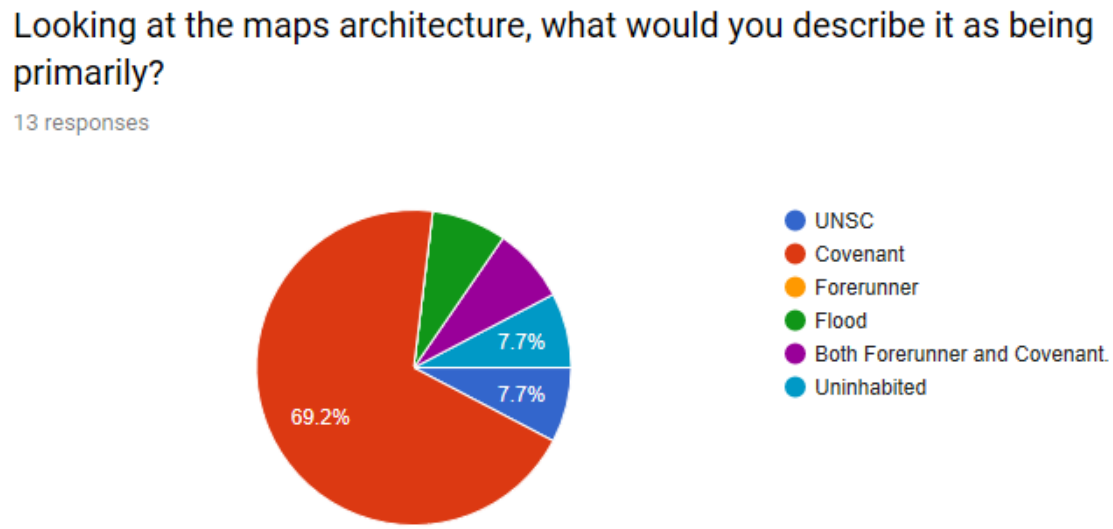
	design (seen in the blood gulch maps from Halo 1,2 and Reach and those snowy maps from Halo 3). High areas for long range combat, while also providing opportunities for close quarters within the hill's varied tunnels. Large enough area to allow for both teams to have vehicles, with a strategic choke point at the middle.	maps Sidewinder and Avalanche (horseshoe shape, along with various tunnels cutting through the middle). The bases on either side of the map are, as stated before, the same structures from Snowbound, the general sandy aesthetic reminds me of Sandtrap. The uneven terrain and protruding rocks acting as cover to move through is similar to various halo maps such as Blood Gulch. One other minor similarity is also how three sides of the map end in cliffs while the back of the map ends in some kind of ocean or lake, this is similar to Valhalla.	maps balanced to the best of their abilities. They rarely have a level where the enemy team / enemy force has too much of an advantage over you which stops you progressing. This map seems to keep the balance allowing each team a fair chance until someone gets the hammer.

Section 3: Pegasi Delta architecture

In this section, carefully use the images provided below to answer the following questions. https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0

Be sure to look at all images before answering the questions.

Question 5:



Please explain:

	Participant 16	Participant 8	Participant 2
Answer to question	Covenant	Covenant	Covenant
Explanation	It would appear to be a human colony that has been under attack/ survey by the covenant, with the bridge and underground bunker being of human construction. But, the more prevalent aspects of the map would appear to be the covenant, with the quite prominent AA gun on top of the plateau. Where the players	The map is almost entirely dominated by the Covenant, the only exception is the small and abandoned UNSC structure. The Forerunners and Flood make no appearances.	With the amount of Covenant structures in this map being in higher quality than UNSC structures, its clearly meant as a more Covenant controlled environment with a previous human presence. It's more as if the area was originally UNSC controlled but then lost to the Covenant who moved in and added their own

	themselves will be spawning and protecting their own bases which are of covenant design. Along with the covenant items stashed away within the caves, and the walk way bits over the pit of death.		structures providing them with a foothold in the area.

Section 4: Pegasi Delta

Question 6

In this section, carefully use the images provided below to answer the following questions. https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0
Be sure to look at all images before answering the questions.

Are there any (unique) aspects of the map that you think stand out when compared to other Halo maps?

13 responses

	Participant 16	Participant 8	Participant 2
Answer to question	I'd say the inclusion of both covenant and human constructions.	The location is very unique	No
Elaboration	Most often a Halo map will stick to a particular faction having 'control' over the area, where you may only see Covenant crates and their slick walls. Whereas, here you have created the idea that there is a grander battle for the planet, over that of a simple	There aren't any Halo maps on Pegasi Delta, and there aren't really that many expansive and open covenant themed maps, Snowbound is rather open but it's also rather small.	There aren't that many features within the map not really providing it enough aspects to look at yet alone unique aspects. The map has a few structures, general canyon rock and an internal cave system / Covenant tunnel system. There isn't really anything popping

	glass and dash tactic so often seen. After all, the covenant has seemingly built structures here within the caves.		out that would make this anymore unique than any other Halo map.

Section 5: Pegasi Delta description

Question 7

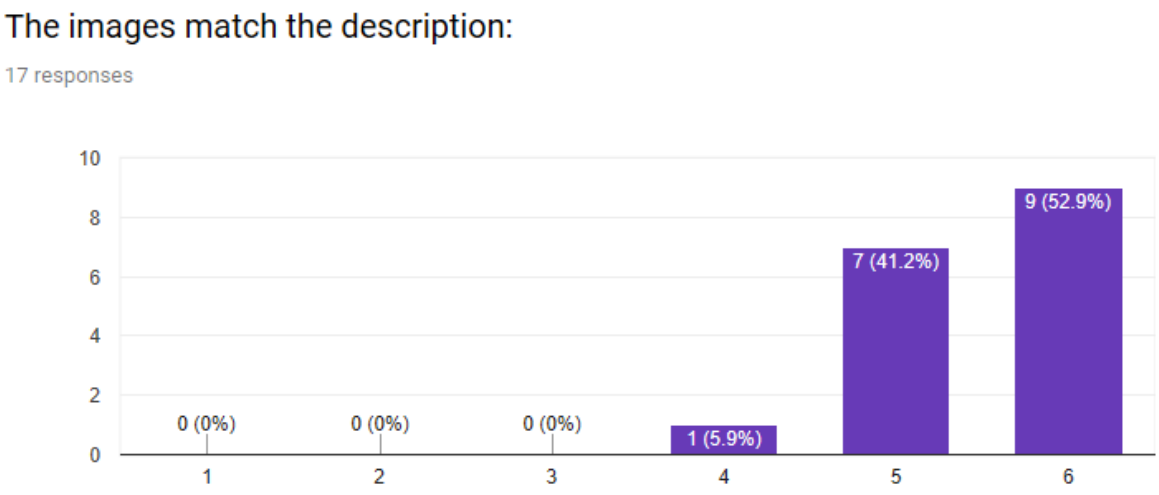
In this section, carefully use the images provided below to answer the following questions.

https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0

Be sure to look at all images before answering the questions.

Please read the following statements and answer on a scale of 1 – 6 where 1 is completely disagree and 6 is completely agree:

Description: "The surface of the world was made of red rocks and sand. Orange dust permeated the sky and had a faint yellow sun. It had seas that were unusually green"



	Participant 16	Participant 8	Participant 2
Answer to question	6	6	5
Elaboration	N/A	The map is indeed covered in red rocks and sand, looks similar to	Even though the map contains the description from above, it still seems

		Mars in a way. There is also a thick orange haze, and the sun is faint enough that it's easily overtaken by the Assault Carrier in terms of presence felt on the map.	like a normal desert map to myself. I think if the rocks had been a bit more red and the sand generally gone towards the red in color as well then it would match the description. For the "unusually green" sea, even though green in color doesn't really stand out too much and looks like a normal sea with a tint of green on it providing it with a sandy color instead.

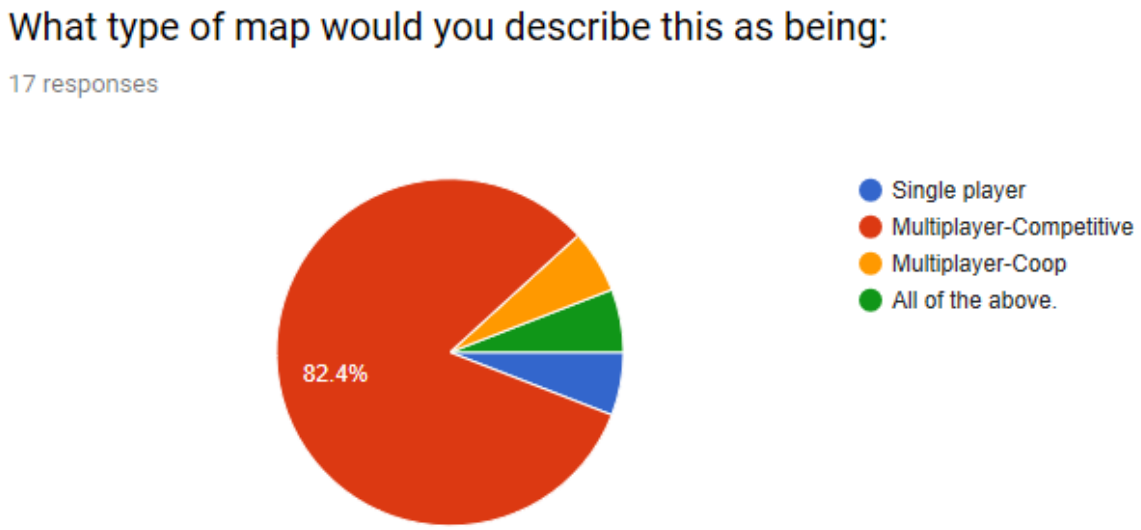
Section 6: Pegasi Delta Map type

Question 7

In this section, carefully use the images provided below to answer the following questions.

https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0

Be sure to look at all images before answering the questions.



	Participant 16	Participant 8	Participant 2
Answer to question	Multiplayer Competitive	Multiplayer Competitive	Multiplayer Coop
Elaboration	There are two bases suitable for game types such as Capture the Flag, with ample space for vehicles. It is similar to the map Avalanche from Halo 3, in the general shape, and design. Which was also perfect for team based objective capturing game types.	It's very similar to Bungie's multiplayer maps, doesn't look like a campaign or firefight map at all.	The general mirroring of the map would give each team a balanced chance at winning.

Note: By participant 2's elaboration, it is probable that they meant to answer Multiplayer Competitive as the elaboration doesn't match the answer provided. However, this cannot be confirmed as not details were left for further questions.

Section 7: Pegasi Delta details

Question 8

In this section, carefully use the images provided below to answer the following questions.

https://www.dropbox.com/sh/3q5o4v1718gp37s/AABtyUK3l7RUeslUIFyJtojta?dl=0

Be sure to look at all images before answering the questions.

Using the images provided, are there any details (objects/assets) currently in the level (or around it) that you thought added a sense of depth to the map?

17 responses

	Participant 16	Participant 8	Participant 2
Answer to question	The bridge	Yes, the orange haze, green seas, Snowbound Turrets, Tyrant AA Gun, and CAS Assault Carrier	The cannon
Elaboration	It adds a much more strategic element to the centre of the map, where the player will have to deal with combat on	The orange haze already adds a good sense of depth, considering that the further things are away, the more obscured they become. The various objects found	It gives the level a bit more of a purpose as to why its worth being in that area. At first you think if its some form of mineral

	the ground as well as potential snipers from above. Plus, it provides cover making it an excellent choke point. And is rather forboding as it towers above the player at quite a height..	throughout the map also has a hierarchy of size in relation to various objects in the map, such as how the small out of boundary turrets can be compared to the much larger Tyrant. The various recognizable structures also add to the scale of the map, since I've seen/entered them throughout various other locations, and have compared them with other objects not found on the map, one example of this is the Tyrant in comparison to the Covenant shield projecting spire in Halo Reach. I have also seen the Snowbound bases on Snowbound before, and while they appear of a moderate size on Snowbound since they take up most of the map, they appear very small on Pegasi Delta. Of course I still haven't mentioned the elephant in the room, or rather, the assault carrier in the sky, which is one of my favourite additions to the map. It really shows how strong of a presence the Covenant have over the planet, as it pretty much dwarfs the entire map. Despite this you can still gauge how far away it is due to how heavily obscured is is by the orange haze. Personally, I think the map does a superior job at conveying scale than some of Bungie's other maps. It	/ resource the Covenant are after but when spotting the canyon you think it more of a strategic point making you want to capture it / win the game.

		manages to make the 5.3 km long Assault Carrier look far larger than the 28.9 km long Super Carrier does in the 6th level of Halo: Reach (Long Night of Solace). In my opinion, only two Bungie levels provide a similar sense of scale: the Truth and Reconciliation in the 3rd level of Halo 1 (The Truth and Reconciliation), and the Forward Unto Dawn when it appears about halfway through Halo 3's 7th level (The Ark).	

Section 8: Pegasi Delta details

Question 9

Additional Feedback

12 responses

	Participant 16	Participant 8	Participant 2
Answer to question	Pretty snazzy map, it would fit well within any Halo game.	N/A	This is a really good attempt at designing and creating a Halo inspired multiplayer map. Even though there are a few things that would need tidying / optimising a bit more, the level is actually at a decent standard. Saying that though there are a few things which could be improved such as general lighting and adding a few more environment pieces such as dead foliage and more Covenant props.

Appendices C: Ethics checklist

Bournemouth University

Research Ethics Checklist

Reference Id	18117
Status	Approved
Date Approved	24/11/2017

Researcher Details

Name	Samuel Williamson
Faculty	Faculty of Science & Technology
Status	Undergraduate (BA, BSc)
Course	BSc Games Technology
Have you received external funding to support this research project?	No

Project Details

Title	3D GAME ENVIRONMENT BASED ON HALO DESIGN WITH ASSET CREATION
Proposed Start Date of Data Collection	13/11/2017
Proposed End Date of Project	21/05/2018
Supervisor	Jose Fonseca
Approver	Jose Fonseca

Summary - no more than 500 words (including detail on background methodology, sample, outcomes, etc.)

Level Design and Environment Art plays a pivotal and prominent role in modern day multiplayer video games. This project will focus on the development and implementation of two video game levels with the addition of asset creation for these environments. The project will implement an original Halo inspired map using techniques derived from Halo environments or other successful titles of a similar genre. This is achieved using a variety of modern Level Design and Environment Art techniques and tools now available in modern Game Engines, as well as cutting edge 3D modelling and Texturing practises. This project will be achieved by the completion of four main stages, Planning & Preproduction, Development & Creation of the visuals of the environments, Implementation and finally, Polishing. This has been chosen as it best suits someone working on the level pipeline individually. This process aims for the author to expand and demonstrate knowledge techniques and skill sets for the Level creation pipeline including Level Design, Environment Art and 3D modelling founded whilst studying Games Technology. The project will be evaluated by industry professionals as well Halo enthusiasts in order to measure success.

External Ethics Review

Does your research require external review through the NHS National Research Ethics Service (NRES) or through another external Ethics Committee?	No

Research Literature

Is your research solely literature based?	No

Human Participants

Will your research project involve interaction with human participants as primary sources of data (e.g. interview, observation, original survey)?	Yes
Does your research specifically involve participants who are considered vulnerable (i.e. children, those with cognitive impairment, those in unequal relationships—such as your own students, prison inmates, etc.)?	No
Does the study involve participants age 16 or over who are unable to give informed consent (i.e. people with learning disabilities)? NOTE: All research that falls under the auspices of the Mental Capacity Act 2005 must be reviewed by NHS NRES.	No
Will the study require the co-operation of a gatekeeper for initial access to the groups or individuals to be recruited? (i.e. students at school, members of self-help group, residents of Nursing home?)	No
Will it be necessary for participants to take part in your study without their knowledge and consent at the time (i.e. covert observation of people in non-public places)?	No
Will the study involve discussion of sensitive topics (i.e. sexual activity, drug use, criminal activity)?	No

Are drugs, placebos or other substances (i.e. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	No

Will tissue samples (including blood) be obtained from participants? Note: If the answer to this question is 'yes' you will need to be aware of obligations under the Human Tissue Act 2004.	No

Could your research induce psychological stress or anxiety, cause harm or have negative consequences for the participant or researcher (beyond the risks encountered in normal life)?	No
Will your research involve prolonged or repetitive testing?	No
Will the research involve the collection of audio materials?	No
Will your research involve the collection of photographic or video materials?	No
Will financial or other inducements (other than reasonable expenses and compensation for time) be offered to participants?	No

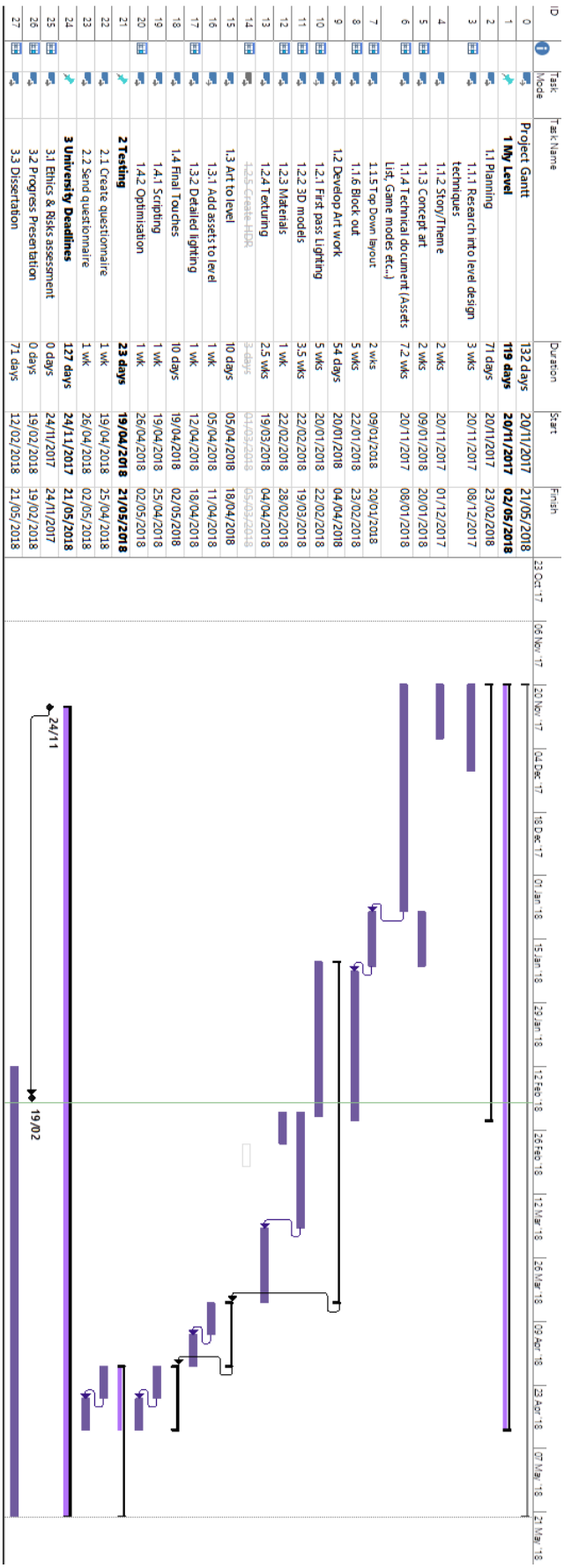
Please give a summary of the ethical issues and any action that will be taken to address these. Explain how you will obtain informed consent (and from whom) and how you will inform the participant about the research project (i.e. participant information sheet).
I will use a public forum to post the detailing information about the research taking place and the outcome of my portfolio project. After this, I will ask them to fill out surveys to gather measurable data. Before this, I will request that any participant fills out a consent form.

Final Review

Will you have access to personal data that allows you to identify individuals OR access to confidential corporate or company data (that is not covered by confidentiality terms within an agreement or by a separate confidentiality agreement)?	No
Will your research involve experimentation on any of the following: animals, animal tissue, genetically modified organisms?	No
Will your research take place outside the UK (including any and all stages of research: collection, storage, analysis, etc.)?	No

Please use the below text box to highlight any other ethical concerns or risks that may arise during your research that have not been covered in this form.

Appendices D: Gantt chart



ID	Task Mode	Task Name	Duration	Start	Finish
0		**Project Gantt**	132 days	**20/11/2017**	**21/05/2018**
1		**1 My Level**	**119 days**	**20/11/2017**	**02/05/2018**
2		1.1 Planning	71 days	20/11/2017	23/02/2018
3		1.1.1 Research into level design techniques	3 wks	20/11/2017	08/12/2017
4		1.1.2 Story/Theme	2 wks	20/11/2017	01/12/2017
5		1.1.3 Concept art	2 wks	09/01/2018	20/01/2018
6		1.1.4 Technical document (Assets List, Game modes etc..)	7.2 wks	20/11/2017	08/01/2018
7		1.1.5 Top Down layout	2 wks	09/01/2018	20/01/2018
8		1.1.6 Block out	5 wks	22/01/2018	23/02/2018
9		1.2 Develop Art work	54 days	20/01/2018	04/04/2018
10		1.2.1 First pass Lighting	5 wks	20/01/2018	22/02/2018
11		1.2.2 3D models	3.5 wks	22/02/2018	19/03/2018
12		1.2.3 Materials	1 wk	22/02/2018	28/02/2018
13		1.2.4 Texturing	2.5 wks	19/03/2018	04/04/2018
14		1.2.5 Create HDR	0 days	04/03/2018	04/03/2018
15		1.3 Art to level	10 days	05/04/2018	18/04/2018
16		1.3.1 Add assets to level	1 wk	05/04/2018	11/04/2018
17		1.3.2 Detailed lighting	1 wk	12/04/2018	18/04/2018
18		1.4 Final Touches	10 days	19/04/2018	02/05/2018
19		1.4.1 Scripting	1 wk	19/04/2018	25/04/2018
20		1.4.2 Optimisation	1 wk	26/04/2018	02/05/2018
21		**2 Testing**	**23 days**	**19/04/2018**	**21/05/2018**
22		2.1 Create questionnaire	1 wk	19/04/2018	25/04/2018
23		2.2 Send questionnaire	1 wk	26/04/2018	02/05/2018
24		**3 University Deadlines**	**127 days**	**24/11/2017**	**21/05/2018**
25		3.1 Ethics & Risks assessment	0 days	24/11/2017	24/11/2017
26		3.2 Progress Presentation	0 days	19/02/2018	19/02/2018
27		3.3 Dissertation	71 days	12/02/2018	21/05/2018