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Effects of 3D Modularity in Multi-person Pipelines

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ABSTRACT

Game development is a complicated process and typically involves several people with different skill sets. Developers employ a variety of methodologies and techniques to solve different problems. How to maintain production speed and high quality are some of the problems that developers face. 3D modularity is a technique often utilized by game developers to assist in solving these problems.

The objective of this thesis was to investigate how 3D modularity is utilized in modern video game production and what effects it has on a multi-person production pipeline. While 3D modularity offers powerful benefits for game production, its utilization should be considered carefully.

During the thesis, qualitative research methods were utilized to investigate the subject and provide answers to the research questions. History analysis was performed to analyse several video games that have utilized modularity in their production pipelines and professional 3D environment artists were interviewed to provide up-to-date information from the industry. The data collected through these methods was analysed thematically to identify core concepts about the subject. This information was utilized during a case study and the results were analysed with a SWOT methodology.

This study explored the implementation of 3D modularity in a multi-person pipeline and suggested what a developer must understand if they are to utilize it in their production. This study also showed that utilizing 3D modularity is not a simple process that comes with other considerations involving pre-planning, communication, iteration and rules.

Keywords: 3D modularity, 3D environment art, multi-person pipeline, trimsheets

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Glossary

Mesh – Collection of vertices, edges and faces that make up a 3D assets surface
Low poly – A 3D mesh that has relatively small number of polygons
High poly – A 3D mesh that contains large number of polygons
Baking – Process of saving information from a 3D mesh into a texture file
UVmapping – The process of projecting a 2D image over a 3D surface
Texture – 2D image projected over a 3D mesh
Texture maps – Contain material attributes such as light information and texture
Normal map – Texture map containing height information baked from a high poly 3D mesh, often used to enhance the appearance and details of a low poly mesh
Texture Blending – Technique where two textures are blended with each other to appear as if they are one and the same
Texel density – Measurement unit describing the resolution of a texture when applied to a 3D object. For example, pixels per meter (256px/m)
Game engine – Software designed for development of video games
Blockout – Act of planning game spaces out with primitive shapes like cubes
Grid – A pattern of lines that cross each other by matching distances, essentially a coordinate plane with X and Y axis
3D Grid – a grid with X, Y and Z axis
GDC – Game Developers Conference
Shader – A computer program that calculates rendering information
Stylized – Visual style that contains exaggerated, non-realistic shapes, proportions, colors or features that create a unique visual style

1 INTRODUCTION

Game production is an extensive and complicated effort which typically involves a lengthy production cycle during which the developers face challenges that vary by complexity (Kennedy 2013; Salmond 2021; Stoneham 2010; Thorn 2013; Thorn 2014). How each of these challenges are solved and who solves them depends entirely on the problem. For example, programmers solve code issues, while 3D artists solve issues with 3D models. (Thorn 2013; Thorn 2014.)

Ultimately, the developers' goal is to be as efficient as possible with their resources. Depending on the issue, they might be solved by an individual. However, in some situations, the problem might involve several employees or even entire production teams. While it is important to solve all problems quickly and efficiently, the more people involved, the more crucial it is for the problems to be solved as soon as possible. (Salmond 2021; Thorn 2013; Thorn 2014.)

Large production teams allow their employees to specialize in individual roles, focusing their workload on one aspect of production at a time. In smaller companies, it is common for a single employee to perform multiple roles simultaneously. (Kennedy 2013; Thorn 2013; Thorn 2014.) Regardless of the company size or the number of employees, some tasks can only be performed in a certain order. For example, in traditional 3D workflow, a 3D artist creates a mesh that is unwrapped before textures can be applied to it. (Watkins 2011, 37.)

In a small company, the individual responsible for these tasks likely is the same employee. As such, they can work without interruptions, moving to the next task after finishing the previous one (Kennedy 2013; Salmond 2021; Thorn 2014). In large companies, it is not uncommon that several individuals are working on the same asset due to specializations in teams (Burgess 2014; Perry 2002; Salmond 2021). In these situations, a texture artist cannot begin their work before the 3D artist has finished the mesh and the unwrap process.

This kind of situation is called a bottleneck, a moment in production where one employee is waiting for another to finish their work before they can begin theirs.

Bottlenecks are a considerable risk, potentially causing massive delays in production times. In a worst-case scenario, a bottleneck can cause cascading effects that influence entire production teams. Companies utilize a variety of ways to avoid bottlenecks, and one such method used in Environment Art is 3D modularity. (Salmond 2021; Investopedia 2024; Thorn 2013; Thorn 2014.) In this thesis, the author investigates how 3D modularity is utilized in video game production and what effects it has on the multi-person production pipeline.

2 THESIS OBJECTIVE AND FRAMEWORK

The author's purpose is to investigate what effects modular 3D workflow has on a multi-person pipeline and how game companies utilize modularity in their productions. The author completes this objective through three phases: introduction, research and production phases. To help visualize the framework of the thesis, the author has prepared a mind map (Figure 1), in which the author describes the overall flow and the process of their thesis.

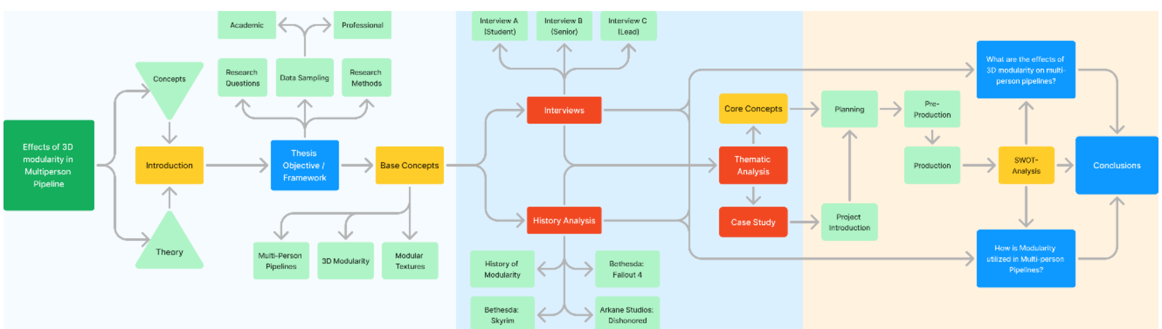

Figure 1. Thesis framework

In the introduction phase (light blue background) the author provides base concepts and necessary foundation information to frame the thesis subject. In the research phase (dark blue background) the author performs a history analysis to investigate how modularity has been utilized in video games, before analysing video games that have utilized modularity in their production pipelines.

Following the history analysis, the author interviews professionals working in the video game industry before compiling the results of their research through thematic analysis. The result of this thematic analysis combines the author's findings from the history analysis and interviews to provide a list of core concepts on the subject. The author utilizes these concepts in their case study during the production phase (light orange background) of the paper before concluding the thesis and answering the research questions.

2.1 Research Context and Questions

The thesis subject was selected by the author based on their interests and skills. During their studies, the author focused on 3D art and level design, and they have some previous experience as an architect. A specialization that combines 3D art and level design is a 3D environment artist, which the author worked as during the various projects they participated in during their studies.

The thesis sub-topic was also selected based on the author’s interests; the author has always been interested in modularity. The author wished to learn more about the subject through their thesis. While the subject has been studied before, the author noticed during the initial research that most of the academic research is focused on the technical aspects of modularity, excluding its effects on the multi-person pipeline.

Therefore, the author investigates how 3D modularity affects multi-person production and how game companies utilize modularity in their production pipelines. As such, the primary research question of the thesis is “What are the effects of 3D modularity on multi-person pipelines?”. The secondary research question is “How is modularity utilized in multi-person pipelines?”.

Answering these questions will provide evidence as to why modular 3D workflow is so commonly used in game production. Additionally, the answers provide insight into what a 3D environment artist must know and consider while utilizing a 3D modular workflow. Lastly, the answers explain what benefits a modular workflow provides for a multi-person production pipeline.

The subject covered by the author in this thesis is complex in nature. Therefore, to answer the research questions, the author utilized qualitative research methods, which are useful tools in providing answers to “how” and “what” questions. Additionally, “why” and “how” are good questions to ask when one attempts to discern a deeper understanding of a subject. (Hennink et al. 2020; Hesse-Biber et al. 2011; Hirsjärvi et al. 2009.)

2.2 Research Methods

Four qualitative research methods were utilized in this thesis to answer the research questions. These methods were history analysis, interviews, thematic analysis and a case study. Three of these methods were employed during the research phase to focus on investigating the modular 3D pipeline and the principles behind utilizing it through history analysis, interviews and thematic analysis. The production phase focused on the case study, which was based on the information gained from the introduction and research portions of the thesis.

The primary research question was answered through a combination of results from all the research methods. The author formed a foundation of base concepts from the base material available in academic books and professional sources, before investigating how modularity is utilized by companies through history analysis and interviews. This information was analysed thematically to provide thematic core concepts that the author utilized during the case study. The results of the project were analysed with a SWOT methodology before the author gave their conclusions and answered the research question. The secondary research question was also answered through the same research methods but focused more on the findings from the research phase.

Interviews and history analysis were chosen as research methods by the author to provide up-to-date and in-depth information from developers that utilize 3D modularity in their productions. According to various researchers, interviews provide high-quality answers to “why and how” questions when performed successfully (Hennink et al. 2020; Hesse-Biber et al. 2011; Hirsjärvi et al. 2009). Results from the history analysis and the interviews also confirmed the fact that modularity is utilized by game developers.

However, the accuracy of the history analysis was dependent on the observations made by the author. This contained a risk that the author misinterpreted the details they observed. To diminish this risk, the author only utilized games as the subject of the research method if he had access to material provided by the game developers entailing details about the game production.

The author analysed the results of the history analysis and interviews thematically to identify recurring themes. A list of core concepts was formed from these themes that the author utilized as the foundation of their production in the case study. Additionally, these core concepts were used as the evaluation criterion for the production. Thematic analysis was chosen for identifying the core concepts, since it is usually applied to qualitative data (Caulfield 2023).

A case study was chosen to test the author's findings and provide detailed information about the application of the identified core concepts. A case study is often implemented in a thesis when qualitative methods are involved. (McCombes 2023). SWOT methodology was used to analyse the results of the production, as it is useful for identifying opportunities for improvement and evaluating the strengths and weaknesses of the product (Raeburn 2024).

2.3 Data Sampling

The author utilized several sources to compile research material that provided a solid foundation for the base concepts and complimented their findings from the research process. The resources are split into academic and professional material. The academic resources are books written by professionals that cover the base concepts of the thesis. The books were selected by subject focusing on environment art and game production, but level design was also used as a criterion because of its connection to environment art (Ahearn 2017; Kennedy 2013; Salmond 2021; Stoneham 2010; Totten 2014).

The professional sources are mostly online YouTube tutorials or official Game Developers Conference (GDC) talks. To ensure the quality of this online material, the author investigated the channels and their authors' backgrounds through

LinkedIn and ArtStation and only utilized material from confirmed professionals with sufficient experience. While choosing books, the author prioritized individuals who have experience working as environment artists or level designers in the game industry and who have experience using the modular workflow.

3 BASE CONCEPTS

Since the author's objective was to investigate how modular workflow influences a multi-person pipeline, the focus of this paper is on the roles directly connected to modular workflow and the people creating or utilizing modular environment assets. Essentially, this means that the author focuses on 3D environment- and texture artists and level designers. However, other roles influence this process and thus the modular assets, but these roles are excluded from the scope of this thesis. In this chapter, the author provides base information on the primary topics: multi-person pipeline, 3D modularity and modular textures.

3.1 Multi-person pipeline

Game development involves a variety of employees working in a diverse set of roles. These employees work individually or in teams, and their responsibilities are as varied as their roles. However, ultimately the work input from all the roles and individuals is combined to produce a video game. (Kennedy 2013; Salmond 2021; Stoneham 2010; Thorn 2013; Thorn 2014.) For their thesis, the author focused on investigating multi-person pipelines in direct relation to 3D modularity.

Essentially, this means that the author did not cover portions of the game production that are not directly involved or influence the modular kits and the work of the environment artist. However, it is still important to understand how the modular kits are influenced by these other roles: game- and level designers, concept- and texture artists and the narrative team (Ahearn 2017; Kennedy 2013; Salmond 2021; Stoneham 2010; Watkins 2011). The author has prepared a mind map to visualize how an environment artist and the modular kit are influenced by these other roles. This map can be seen in Figure 2.

However, the connections and workflow described in Figure 2 are generalizations. In truth, the responsibilities of the roles and how the workflow functions and the names of each role vary from company to company (Salmond 2021; Thorn 2013; Thorn 2014; Watkins 2011). For example, Arkane Studios employs a role called Level Architect in addition to the roles of Level Designer and Environment Artist in their level production pipeline (Zenimax 2019).

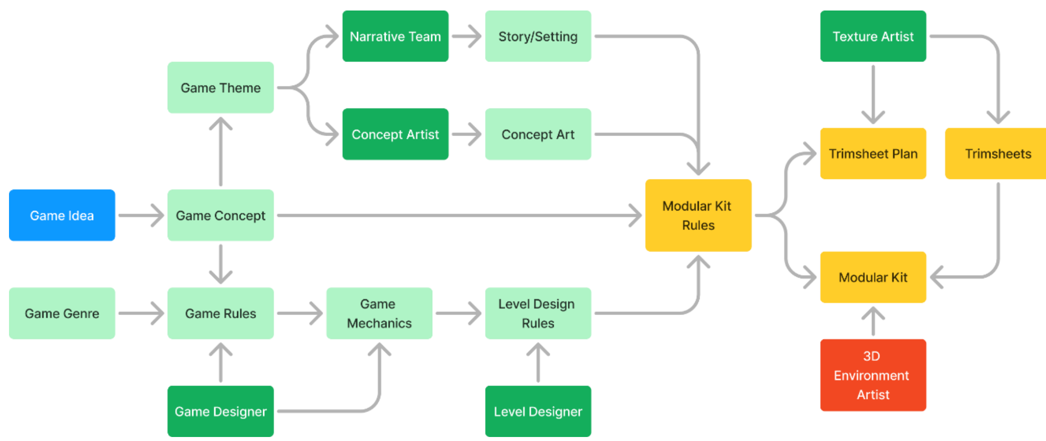

Figure 2. Multi-person pipeline connections

Figure 2 visualizes the connections between environment artists and the roles that work with them or influence the environment artist. Video game production typically starts with an idea that leads into a game concept, which determines things like the game theme and genre. A game designer designs the game mechanics and rules based on the game genre and concept. The game mechanics then directly influence level design rules that a level designer must consider while designing and blocking out the spaces where the gameplay takes place in. (Ahearn 2017; Kennedy 2013; Perry 2002; Salmond 2021; Thorn 2013.)

How these environments appear visually is influenced by the theme of the game, which is often a part of the original game idea or concept. This theme directly informs concept artists and the narrative team about the game style and setting. Game art and story should complement the game's setting and genre; art has a considerable impact on the game feel and experience it provokes from the player. Additionally, the environments and textures in the video game should visually reinforce the game's setting, story, narrative and game mechanics. (Ahearn 2017; Kennedy 2013; Salmond 2021; Totten 2014.)

The environment- and texture artist must consider these factors during production to ensure that the product fulfils the requirements set by the other members of the team. They are responsible for the creation of the environment assets that are implemented inside the game engine to assemble the game environments. These environments are commonly built using modular assets for a variety of technical reasons, but the technique also provides benefits to a multi-person pipeline. (Ahearn 2016; Ahearn 2017; Kennedy 2013; Perry 2002; Salmond 2021; Thorn 2013; Thorn 2014.)

3.2 3D Modularity

3D Modularity is a modelling technique that can be utilized by 3D artists when creating assets. If a 3D asset is modular, its mesh and textures will tile with other compatible modular pieces, essentially combining the two assets seamlessly. (Ahearn 2016; Kronenberger 2020; Norris 2016.) An example of this is shown in Figure 3A with a modular wall and floor. The same asset used in image B shows how the wall and floor assets tile with themselves, the teal lines indicating where the seams are between the three meshes.

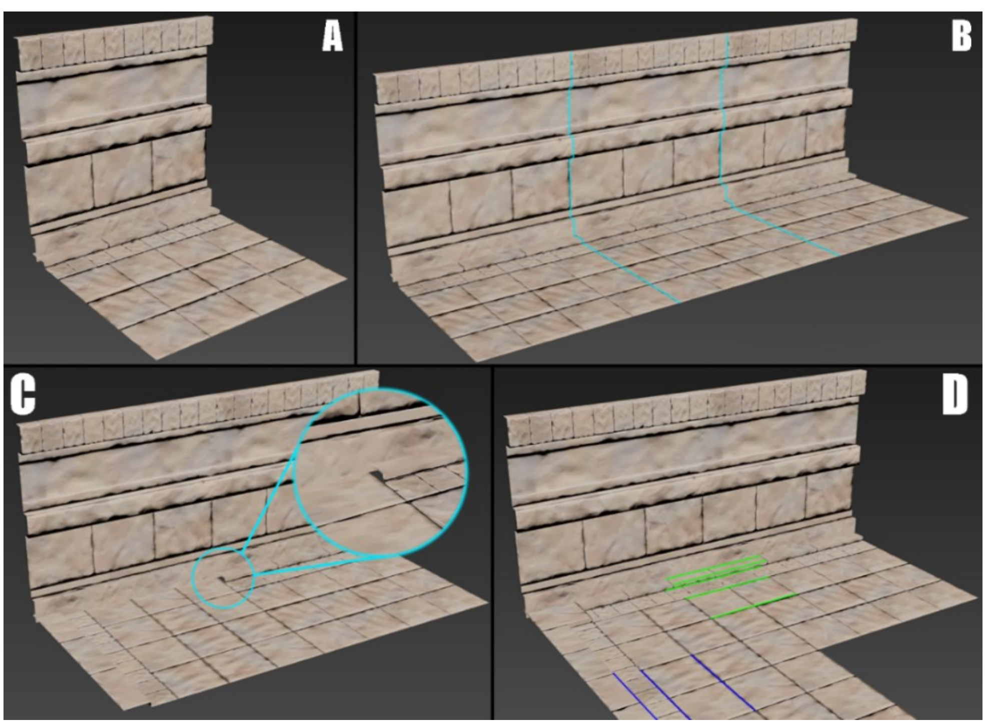

Figure 3. Modular asset

However, there are some limitations and considerations related to this technique. For example, the number of combination possibilities for modular pieces is determined by how the kit is designed to be used (Burgess 2014; Burgess & Purkeypile 2016; Kronenberger 2020; Norris 2016; Perry 2002). An example is shown in Figure 3C, where the floor fails to tile with its neighbour. This floor piece will only tile with itself along one axis; to rotate this asset, a separate corner piece must be made which is shown in image D. The corner piece allows for a seamless connection between the previous floor piece (green) and the floor piece that has now been turned 90 degrees (blue).

Modular kits are designed for a specific function; for example, they are commonly utilized with buildings in which case the kit could be designed to construct interiors or building facades depending on the extent of the kit (Arellano 2024; Burgess & Purkeypile 2016; Kronenberger 2020; Norris 2016; Perry 2002). Some examples are shown in Figure 4; image A contains a modular kit for creating dwarf-themed buildings and tunnels from the video game Skyrim (Burgess 2013) and image B which is a modular kit for assembling a variety of different types of office tables (Kronenberger 2020).

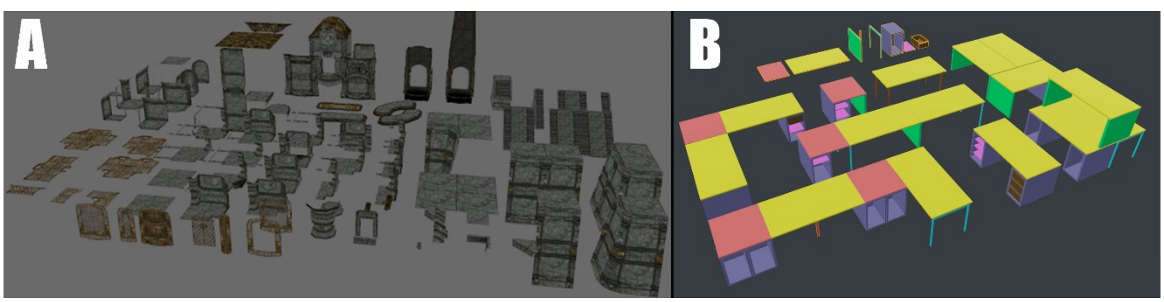

Figure 4. Types of modularity (Burgess 2013 & Kronenberger 2020)

Modular assets are often compared to Lego pieces, which share many similarities with them. Similarly, Lego’s modular assets can be combined in different ways to assemble a variety of combinations. Typically, a modular kit allows several combinations far exceeding the number of individual 3D assets in the kit itself, and they can be combined with other modular assets if they have a matching grid, providing further combination possibilities. (Arellano 2024; Kronenberger 2020; Perry 2002; Salmond 2021; Thorn 2013; Thorn 2014; Totten 2014.)

Another consideration of modularity is constant repetition. Extended use of the modular assets results in obvious repetition, which can negatively impact the visual quality and game feel. To negate this, developers utilize a variety of methods including blending the modular pieces or seams with unique assets, shaders to create texture variations, employ variant assets and textures or blend modular kits together with kit-bashing. (Ahearn 2016; Ahearn 2017; Arellano 2024; Burgess 2013; Burgess 2014; Burgess & Purkeypile 2016; Gahan 2011; Kronenberger 2020; Norris 2016; Perry 2002; Salmond 2021.) However, exploring these methods in detail is beyond the scope of this thesis as these topics contain an extensive amount of information; but the author considered that mentioning these techniques is important.

The last consideration regarding modularity is kit rules, which an artist must follow while creating modular assets. These rules include pivot placement, pre-established grid, kit footprint, kit complexity and tiling. Otherwise, the kit will be challenging to work with during implementation and the assets may tile incorrectly or otherwise be incompatible with other modular assets within the kit. This will result in production delays when the artist fixes the problems or slows production through difficulty of use. To avoid this, the kits should be tested early and consistently throughout the modelling process by the modeller, but also by the people that will utilize the kit. (Arellano 2024; Burgess 2014; Burgess & Purkeypile 2016; Kronenberg 2020; Norris 2016; Perry 2002; Salmond 2021.)

An early consideration is to determine the grid size and the location of pivot points. Grid size determines what size the modular assets will be and how the modular components snap together. The grid size should be a power of two number like 2,4,8,16 or 32 and so on. This makes tiling easier with other kits that share a grid size along the geometric sequence. As an example, a kit with a grid of 2 meters will fit twice within a 4-meter grid. Similarly, an 8-meter asset can be embedded in a smaller 4-meter grid by taking up two slots. (Ahearn 2016; Arellano 2024; Burgess 2013; Burgess 2014; Burgess & Purkeypile 2016; Kronenberger 2020; Perry 2002; Salmond 2021.) However, while the assets do not have to be uniform, these non-uniform pieces should be used with consideration or avoided entirely as they can result in complications. An example of this can be seen in Figure 5. While non-uniform pieces tile with each other, problems often occur when the pieces are rotated (Burgess & Purkeypile 2016).

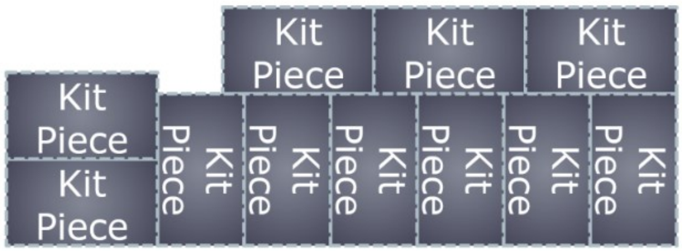

Figure 5. Non-uniform footprint problem (Burgess & Purkeypile 2016)

All 3D assets have a pivot point in relation to which the objects transform, rotate and scale. The pivot point of a modular asset is typically against the ground plane and against one corner of the object. This allows for easy tiling by snapping the object against the grid. An example of this is shown in Figure 6A, which shows two modular assets on a 4-meter grid with their pivot points marked. (Ahearn 2017; Arellano 2024; Burgess 2013; Gahan 2011; Thorn 2013; Thorn 2014.)

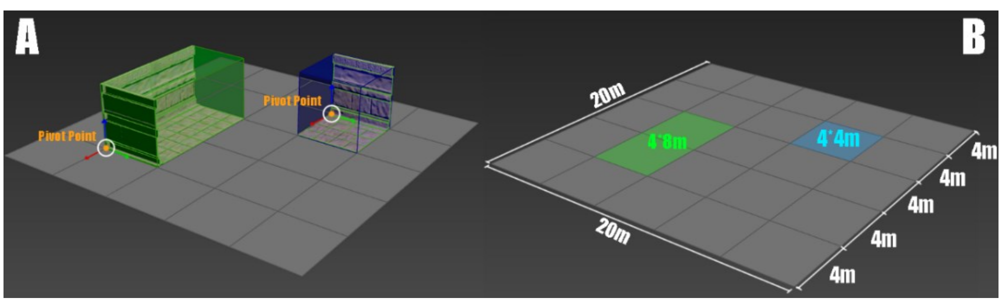

Figure 6. The grid, footprint and pivot point

The two highlighted zones on the grid in Figure 6B are image A’s asset footprints. The footprint is the modular asset base size, the area which the asset occupies: the green asset’s footprint size is 4 by 8 meters and the blue asset’s is 4 by 4 meters. A modular asset should always be modelled so that its mesh stays inside the bounds of its footprint; otherwise, the asset will clip through the adjacent meshes (Burgess 2013; Salmond 2021). An example of this is shown in Figure 7A, while image B shows the asset from image A modified to exist within its footprint, preventing the clipping with its adjacent assets.

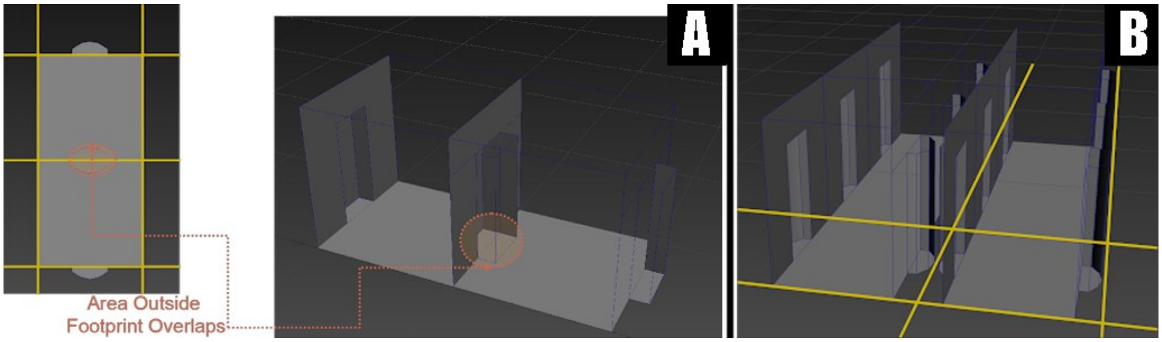

Figure 7. Footprint overlap (Burgess 2013)

The complexity of a modular kit means how small the individual components of the modular kit are. A modular kit intended to build structures could contain wall assets and variants that the developer can choose from while assembling the buildings. Simultaneously, a more complex modular kit could have the wall assets themselves be modular, allowing the developer to select the components of the walls to vary the available walls to assemble the buildings with. (Arellano 2024; Burgess & Purkeypile 2016; Kronenberger 2020; Perry 2002; Salmond 2021.)

An example of a complex modular wall is shown in Figure 8. The sections highlighted in blue, are 1 by 4-meter wall strips, which can be layered on top of one another to form a 4 by 4-meter wall section. The pieces are interchangeable with each other, so the developer can assemble them in any order they wish. Through complexity, it is possible to layer modular kits within each other, enabling a considerable number of iterations. However, it is important to note that a layered and complex modular kit is more laborious to utilize than a simple kit.

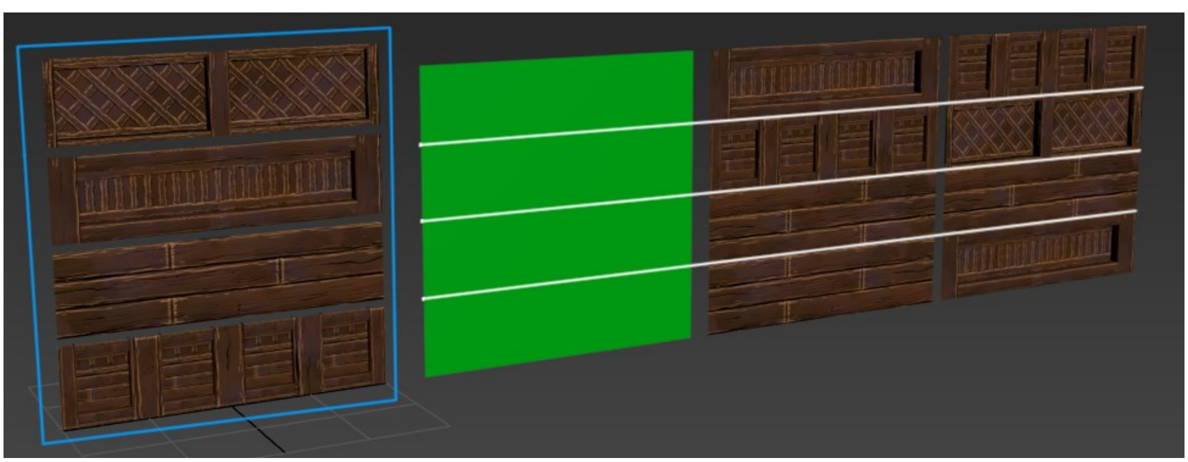

Figure 8. Modular kit complexity

Earlier video games utilized modular methods because of limitations imposed by the technology available at their time (Hutchison 2008). Modern modularity is partially utilized for the same reason. However, there are other advantages to using this workflow, which are more important for game developers. Modularity is used in modern productions because of its influence on production speed, game engine performance and the benefits it offers towards multi-person pipelines, particularly environment artists and level designers. Modular workflow enables level designers and environment artists to work simultaneously, unlike the traditional 3D workflow. (Ahearn 2016; Ahearn 2017; Arellano 2024; Kennedy 2013; Kronenberger 2020; Perry 2002; Salmond 2021; Thorn 2013; Thorn 2014; Watkins 2011.)

To compare the advantages of modular workflow against the traditional 3D workflow, the author has prepared a flowchart to visualize the differences between the two pipelines. This flowchart can be seen in Figure 9, with the traditional production pipeline in section A and the modular pipeline in section B. However, as mentioned in Chapter 3.1 workflows vary depending on the company and the workflows described here are generalizations.

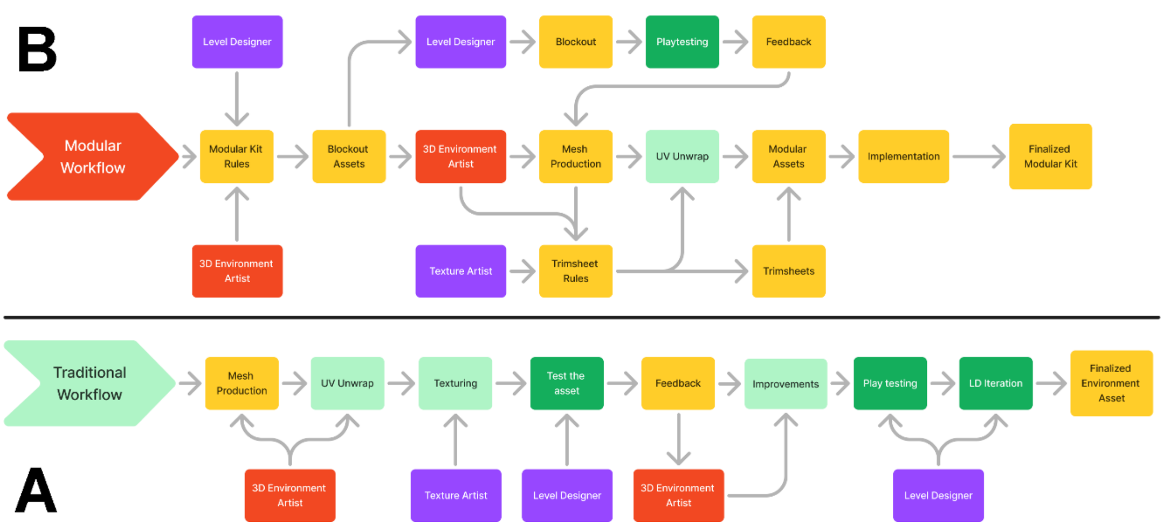

Figure 9. Workflow differences

The traditional 3D production pipeline shown in Figure 9A, follows a linear model where a 3D asset is first modelled by an artist and then the mesh is UV unwrapped and then textured by a texture artist. However, the textures cannot be created before the 3D asset. Any changes done to the mesh would result in changes in the UV unwrap, resulting in the texturing having to be redone. In a linear approach, the textures cannot be created before the 3D artist has finished and unwrapped the mesh, which potentially results in a bottleneck.

The same applies to the level designer; if they utilize an asset in the design process and modifications are done to the asset, the level designer must modify their layout to address any issues. This problem will occur if changes are done to the 3D assets footprint or pivot point. Additionally, when building a map, a designer could identify an asset that is not needed but if the asset was already modelled before, work time will have been wasted on an asset that was not required. (Burgess 2013; Burgess 2014; Burgess & Purkeypile 2016; Salmond 2021; Thorn 2014.)

However, these situations are extremes and developers have methods available to avoid such circumstances. Individuals who work further along the chain typically have other assignments while waiting for the earlier work to finish. However, project planning and management are critical to avoid the bottleneck situations and not all problems can be foreseen. (Thorn 2013; Thorn 2014.)

Figure 9B showcases the modular workflow for creating environment assets. At the start of the project, level designer and the environment artist establish modular kit rules which are utilized in the basic blockout assets. Level designers utilize these modular blockout pieces to build their levels inside the game engine. These blockouts are used by the designers to test and iterate their designs. Early testing allows the level designer to spot potential problems so that they can be addressed and fixed early to avoid problems later in the production pipeline. (Burgess 2014; Burgess & Purkeypile 2016; Perry 2002; Salmond 2021; Thorn 2014; Totten 2014.)

Simultaneously, while the level designer works on the blockouts the environment and texture artist determine trimsheet rules. Once these rules are established, the environment artist can work on the proper 3D assets and unwrap them to the planned texture grid. Modular pieces and textures require constant testing, feedback and iteration from all the involved individuals during the development. If any issues are noticed, the related employee should be informed as soon as possible so that the issue can be addressed. Once the assets are finished, the blockout pieces can be replaced with the new versions. If the kit was designed and modelled correctly, the changes should apply to all levels assembled with the blockout pieces requiring minimal work to address any errors. (Ahearn 2016; Burns 2023; Kennedy 2013; Norris 2016; Perry 2002; Thorn 2014.)

Compared to the linear workflow the modular pipeline carries fewer risks, but requires the employees to communicate, plan, coordinate and follow the established rules. It does require more initial planning, but modularity offers considerable potential for production teams that involve large numbers of employees, allowing individuals to work simultaneously without bottlenecking production. The modular method is also scalable and can be utilized in both small- and large-scale productions by both companies with few employees, large production teams or even individuals. (Ahearn 2016; Burgess 2014; Burgess & Purkeypile 2016; Kronenberger 2020; Perry 2002; Salmond 2021; Thorn 2013.)

Additionally, there are other applications where an individual can utilize modularity. An individual artist can utilize modularity through production kits to increase their production speed. Production kit is essentially a modular kit utilized inside 3D software, instead of the game engine. Additionally, modularity can be used with procedurally generated content to generate vast amounts of environments or assets. However, the author has excluded these topics from the thesis but considered them worth mentioning. (Estrallado 2024; Reveron 2020.)

3.3 Modular Textures

Texture artists can also apply modular methods in their workflows. There are three types of modular methods that can be utilized in texture creation: tiling textures, trimsheets and texture grid. A tiling texture is a texture that does not have a visible seam when placed adjacent to itself, potentially repeating the texture indefinitely. For a texture to be considered tiling, it must tile at least in one direction, but a texture can tile in multiple ways, either horizontally, vertically or in a combination of the two. (Ahearn 2016; Ahearn 2017; Gahan 2011; Stoneham 2010; Watkins 2011.) An example of tiling textures is shown in Figure 10. The image contains a wall built in a 4x5 grid with various tiling textures. The middle rows tile in all directions, while the top and bottom rows tile in three directions. The textures applied to the wall can be seen on the left side of the image.

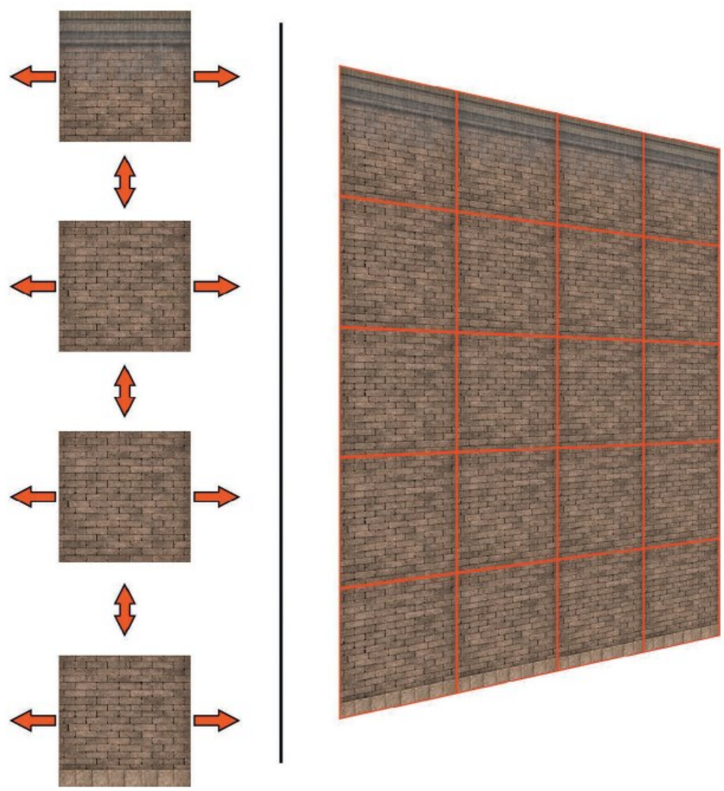

Figure 10 Three- and four-way tiling (Ahearn 2016)

Tiling textures are useful for covering large surfaces with only a single material assigned to them; they allow the artist to cover a large surface with minimal texture size and maintain high texel density with large in-game assets without bloating the texture file sizes. However, in addition to being seamless the texture should not contain any repeating details as these details would make the repeating pattern obvious; but like 3D modularity there are several methods how this repetition can be hidden. These methods include texture blending, texture variations and seam hiding. (Ahearn 2016; Ahearn 2017; Arellano 2024; Burgess 2013; Burgess 2014; Burgess & Purkeypile 2016; Gahan 2011; Kronenberger 2020; Norris 2016; Perry 2002; Salmond 2021.)

However, exploring these blending methods in detail is beyond the scope of this thesis, but an example of tiling materials applied to large surfaces is shown in Figure 11. The same image also shows examples of how texture variations can be utilized to hide the constant repetition of tiling textures. The primary brick wall and ceramic tile textures are identical with the wall and floor textures. However, the secondary details, such as the vents or cracks, are varied.

Figure 11. Tiling textures (Ahearn 2016)

Another modular texturing method is a trimsheet, which is essentially a combination of tiling or unique textures sharing a UV space. An example of a trimsheet and its application is shown in Figure 12. Image A contains the trimsheet texture, while images B and C showcase applications of the trimsheet. A Singular trimsheet can potentially be used to texture a variety of different assets or environments with very minimal extra work.

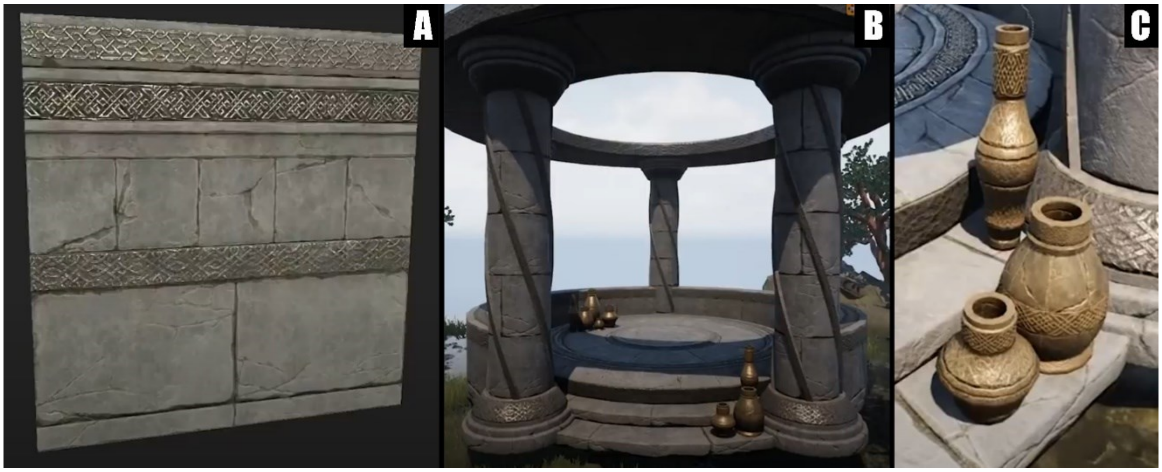

Figure 12. Trimsheet example (Simpson 2019)

Trimsheets can be used for a variety of purposes, including decal sheets and texturing 3D assets. Like tiling textures, trimsheets are an efficient way of maintaining a 3D asset's texel density without bloating the texture file sizes, as texture UV space can be re-used. The main difference between trimsheets and tiling textures is that trimsheets cannot tile in multiple directions and they are best used for thin assets or surfaces while tiling textures function on large surfaces and can tile in all four directions. (Dries 2023; Burns 2023; McSherry 2024.)

Trimsheets and tiling textures can also be utilized to reduce the overall number of textures used by video games. Additionally, they can be employed to reduce the total number of materials implemented inside the game engine. This makes the game more optimized by reducing the overall number of draw calls resulting in better performance and higher FPS. (Ahearn 2016; Arellano 2024; Burns 2023; Kronenberger 2020; Thorn 2013.)

The last modular texture method is a texture grid. When textures are created following a texture grid, they become interchangeable with one another. This allows the developers to freely change the textures between each other during development, allowing them to create asset variations without extra work. The grid also makes applying textures to modular assets easier. This logic applies to both tiling textures and trimsheets. (Ahearn 2016; Ahearn 2017; Burns 2023; Kronenberger 2020; Norris 2016.)

Examples of texture interchangeability are shown in Figure 13. Image A contains two trimsheets, one for metal panels and the other for a variety of stone bricks with matching layouts on both. Image B shows two tiling materials, ceramic tiles and a brick wall, both of which have matching grout lines. The utilized grids have been marked by white lines. (Norris 2016.) By designing the textures to follow a grid, the developer can freely change them between assets with matching UVs resulting in additional variants without extra effort.

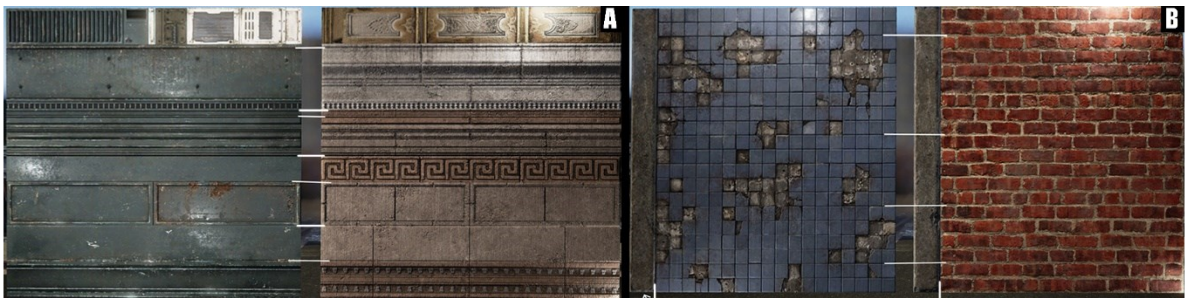

Figure 13. Interchangeable textures (Norris 2016)

In some companies, an environment artist might be responsible for creating textures, but some companies utilize separate texture artists. The benefit of utilizing a UV layout for textures allows the texture artists to work simultaneously with the 3D environment artist. The environment artist can unwrap their assets into the UV layout before the textures and trimsheets are finalized. Once the textures are finished, they can be implemented inside the game engine and the materials assigned to the assets. If the layout was utilized properly, the textures should work directly without problems. (Ahearn 2016; Ahearn 2017.)

Like 3D modularity, this texture workflow requires communication, planning and continual coordination from the people implementing it. Even so, it offers considerable potential benefits for production teams, particularly teams with many employees. It is also scalable and can be effectively utilized by small and large companies or individuals alike. (Ahearn 2016; Burgess 2014; Burgess & Purkeypile 2016; Kronenberger 2020; Perry 2002; Salmond 2021; Thorn 2013.)

However, the most substantial benefit gained from the modular texturing technique is achieved when production teams utilize the modular texture workflow in combination with the modular 3D workflow. The two pipelines complement each other remarkably well. If they are successfully applied to development, a limited number of individuals can create a considerable variety of assets in a short period of time, with limited effort. (Ahearn 2016; Burgess 2013; Burgess & Purkeypile 2016.)

In addition to the benefits of production, modular textures provide a considerable amount of performance and qualitative benefits to the game engines. These benefits include a lower number of utilized materials and draw calls, and increased resource efficiency in production costs. Additionally, it can result in increased asset quality since more time can be allocated to fewer assets. (Burns 20203; Kronenberger 2020; Perry 2002.)

4 HISTORY ANALYSIS

As part of the qualitative research for their thesis, the author performed a history analysis of modularity in video games. First, the author investigated how modularity has been utilized in the past by the video game industry and how it is now utilized by modern video game companies. Following this investigation, the author analysed three video games that have utilized modular workflow methods in their production pipelines. The games were selected based on multiple criteria.

First, the companies that produced the games should have employed an extensive number of employees and utilized a multi-person pipeline. Secondly, they should have utilized modular methods in their production pipeline. Thirdly, the author prioritized games that have material released by the developers about their production methods. The author investigated the game’s usage of modularity primarily through in-game observations. However, they complemented their findings with the material released by the original developers. The usage of this material allowed insight into their production workflow, which the author would not have had access to by only relying on their observations.

4.1 History of Modularity

Modularity is a concept utilized in various ways; particularly modular construction in the real world is what resembles modularity in video games the most. Modular construction essentially means building from prefabricated pieces that are then assembled on location (Totten 2014, 90). This is exactly how it functions for some video games, where an artist prepares the assets in 3D modelling software which are then assembled in a modular fashion inside the game engine.

Previously this method was mandatory for video games due to technical limitations imposed by lack of processing power in hardware available at the time (Hutchison 2008). Most old video games relied on repeated or tiling textures to simply function. An example of this can be seen in Figure 14, which contains three screenshots from the original Doom, which was released in 1993.

Figure 14. Old game tiling textures (Doom 1993)

The images show multiple tiling textures. In image A the metal panels (yellow) are repeated in the interior and exterior walls, also the pillars (green) share their textures which are evident from the moisture leaks in the same position of each pillar. In image B the highlighted metal panels with details (teal) repeat on the far wall, the same panels can be seen repeating in image C in addition to the repeating details on the ceiling (orange).

Old games repeated assets and textures to optimize performance. This is because games are rendered in real-time, which is a considerable amount of processing considering that each scene should be rendered multiple times a second. This is called Frames Per Second (FPS), and it is usually considered as a criterion when considering the game’s performance. (Ahearn 2016; Ahearn 2017; Kennedy 2013; Salmond 2021; Watkins 2011.)

With technological improvements, hardware is capable of much more in terms of processing power and visual quality. However, video game companies continue to utilize modularity in their production. This is because players expect much higher visual quality from their games and the other considerable benefits that modularity provides for the production pipeline. (Ahearn 2016; Perry 2002; Kennedy 2013; Watkins 2011).

Modularity increases production speed, allows designers to work simultaneously with the artists and makes games more optimized by reducing the number of textures and materials that are needed (Ahearn 2016; Ahearn 2017; Perry 2002; Kennedy 2013; Thorn 2013; Thorn 2014; Watkins 2011). Modularity also allows a considerable number of combinations to be made from a low number of pieces, this allows artists to dedicate more time to individual pieces, resulting in higher quality work being achieved in less time when the assets are re-used. (Perry 2002; Kennedy 2013; Thorn 2013; Thorn 2014; Watkins 2011.)

4.2 Bethesda Game Studios: The Elder Scrolls V, Skyrim

The first video game that the author analysed is the critically acclaimed The Elder Scrolls V, Skyrim. It was initially released on 11 November 2011, but has since then been re-released multiple times by the developer Bethesda Game Studios. The author chose Skyrim as a subject for analysis on account of several factors.

Bethesda Game Studios is known for its extensive use of modularity in its games. Skyrim was originally released in 2011 and as such, it has a substantial amount of material available about its development process. The author found multiple GDC talks and articles by the game’s environment artist Nate Purkeypile and lead level designer Joel Burgess describing how modularity was utilized in Skyrim. Lastly, Bethesda Game Studios at the time of working on Skyrim employed around 90 employees in total (Burgess 2013).

While playing Skyrim, the author noted several likely applications of modularity either in the assembly process or as development kits. One distinct observation that the author made was that the developers utilized multiple kits for a variety of different purposes: building exteriors, interiors and dungeon interiors. Figure 15 displays images of building exteriors from the Whiterun settlement, featuring a variety of repeating assets that are likely modular components.

Figure 15. Whiterun modular buildings (Skyrim 2016)

Most of the buildings in the city are built using matching 3D models and similar textures. Variety has been created by mixing components in different ways and by using variant textures. However, the author has no way of confirming if they were assembled as a modular kit inside the engine or as development kits inside 3D software. The roofs, variety of wood and stone wall components of the buildings and porches of the buildings are modular, as their meshes are identical.

Figure 16 showcases an interior of the Blue Palace inside Solitude. The walls and floor that are visible in image A follow a uniform grid footprint, which is highlighted in teal. On close observation the textures of each grid piece match their neighbours precisely, these repeating details are encircled with green in image B. Additionally, this texture repetition is evident between variant pieces such as the windowed wall and arched wall sections. The roof which is visible in image B also tiles on the grid that match that of the floor from image A.

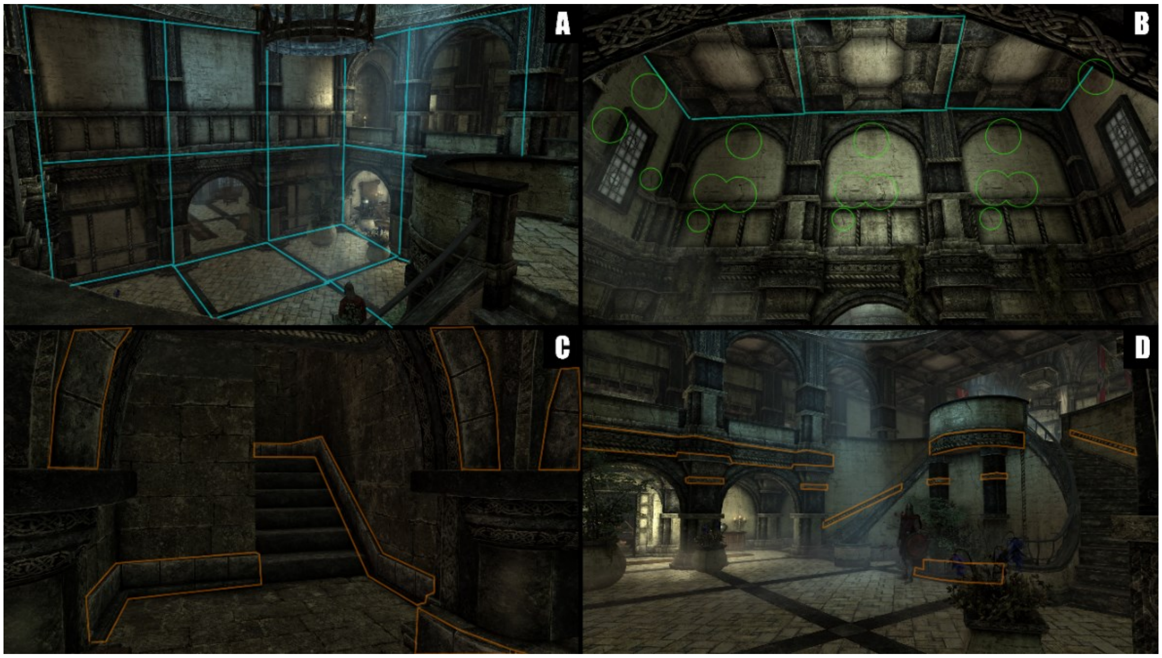

Figure 16. Bluepalace modular assets and textures (Skyrim 2016)

The author also observed repeating textures that likely originate from trimsheets. These are highlighted in orange in images C and D and commonly occur in railings, wall trims and arch details. While most of the assets shown in images A through D are repeating in nature, the large stairwell shown in image D could be a uniquely modelled hero asset. However, it is more likely a more complex modular asset, for it matches the grid perfectly and utilizes the same materials as the rest of the assets inside the building.

Figure 17 is from inside various Skyrim dungeons featuring modular underground ruins, tunnels and large rooms. Image A showcases a tunnel with repeating side pillars highlighted in green and a broken pillar variant in red alongside a tiling stone floor texture. The stone floor texture can also be seen in image B alongside several repeating pillars, stone arches and roof supports, which are highlighted in teal. Image B also has a unique runestone asset in the middle in yellow, and repeated wood assets that match the location’s grid size, highlighted in green.

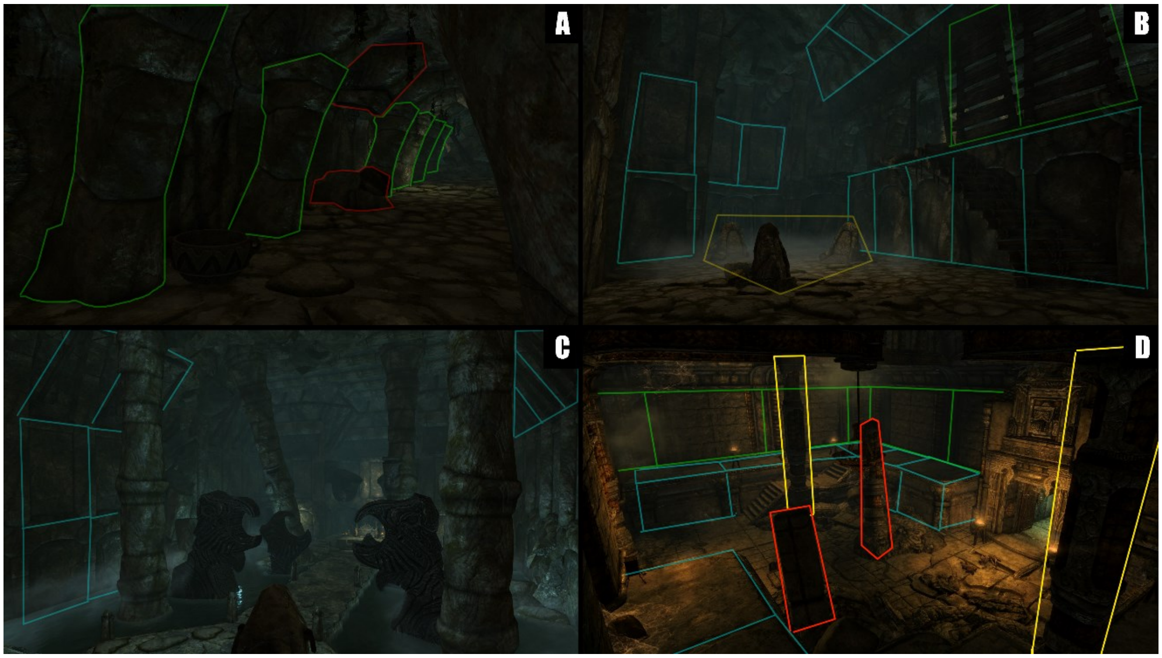

Figure 17. Dungeon modularity (Skyrim 2016)

While image C appears unique, the scene is also built from a modular kit. The room has been assembled with the same teal wall arches, panels, and wooden roof support pieces that can be seen in image B. Image D shows a different dungeon style, which is also assembled using modular assets. A grid can be established from the floor tiles, which are highlighted in teal. Additionally, most of the walls in the room are modular, highlighted in green. The yellow pillars that support the room are also repeating, with broken variants highlighted in red.

In addition to the different use cases of modular kits, the author also noted differences between the kit styles. The buildings of each major settlement have their own visually distinct, unique modular style, which can be seen in Figure 18. Image A is from Whiterun and the modular houses there have distinct yellow roof tiles, and their walls are made from either cobblestones or differently coloured wooden planks and beams. Image B is from Windhelm where the houses are made from brickwalls, a mixture of logs and planks and the roofs have distinct dormer windows.

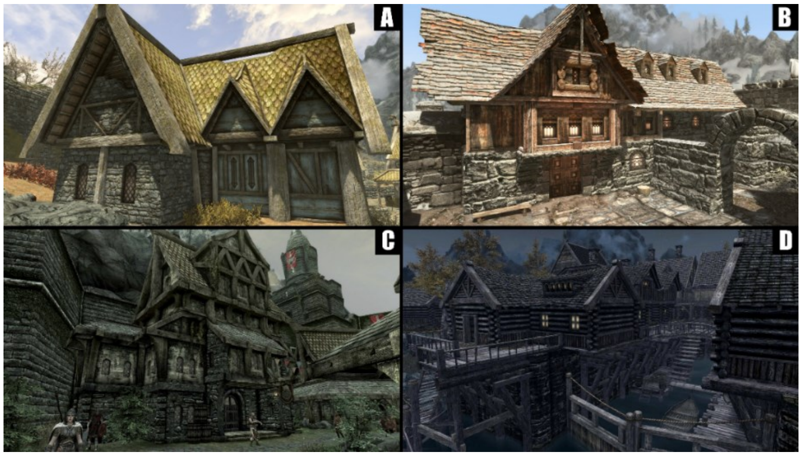

Figure 18. Skyrim modular kit styles (Skyrim 2016)

Image C is from Solitude where the buildings contain three or four floors compared to the one or two of other cities. Additionally, the buildings often have porches and the most common building materials are stone bricks and wooden planks. In Riften, which can be seen in image D, the buildings are mostly log cabins built from wooden logs, and they are built around a multi-floored dockyard that features waterways, canals and elevated wooden walkways and bridges.

The distinct styles trait was shared by modular dungeons; the author identified three dungeon styles: natural caverns, underground ruins and dwarven ruins which are shown in Figure 19. Image A is a natural cavern built with modular assets, the room in the picture is joined by hallways highlighted in green. Bethesda built its caverns by using a blending method, which hides the seams of the modular components and makes the caves appear natural (Burgess 2013).

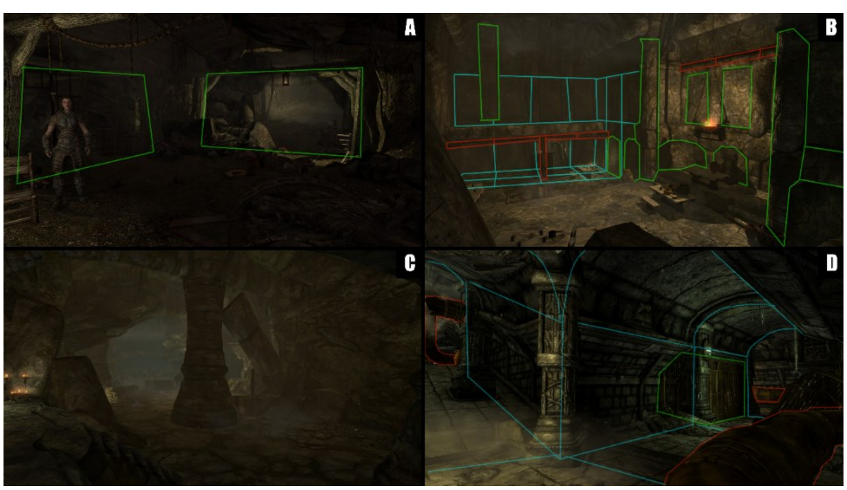

Figure 19. Skyrim dungeon styles (Skyrim 2016)

Image B is from a Nordic crypt and features tunnels and halls. Their style often incorporates stone slabs and pillars highlighted in green, with occasional wooden supports in red. For some of these spaces, a grid used for the modular kit is easy to establish. In image B this grid is shown in teal. The underground Nordic ruins kit is often blended with cave assets that can be seen in image C, which features a natural cavern mixed with stone pillars and partially collapsed walls.

The third dungeon style is shown in Image D. It features a dwarven-style underground dungeon with geometric platforms and repeating stone materials. The dwarven style is easily recognizable by the bronze details highlighted in green and the metal pipes highlighted in red that are commonly observed in their dungeons. The tunnel also adheres strongly to a grid because of its geometrical nature, this grid is shown in teal.

In his articles, Burgess notes that due to Skyrim's scale, Bethesda relied heavily on modularity to scale the art team's production speed. The game consists of 25,7 square kilometres (16 square miles) of Overworld, five major cities, 300+ dungeons, 140+ points of interest, 37 towns, farms and villages. The game was created by around 90 people, which were divided between production teams. Out of the team, seven individuals were environment artists and six level designers. With such a small production team involved with environments directly, modularity was the only solution that made the production of such a vast world realistically possible within the given timeframe. (Burgess 2013; Burgess 2014.)

4.3 Bethesda Game Studios: Fallout 4

The second game the author analysed was Fallout 4. Like Skyrim, it is from the Bethesda Game Studios. Developed as a sequel to Fallout 3, it was initially released on 10 November 2015, four years after Skyrim. The author chose Fallout 4 as the second subject for the history analysis partially for the same reasons as Skyrim. The author had access to multiple articles from the game's developers and Bethesda Studios development team size was around 90 people (Burgess 2013; Burgess 2014; Skyrim 2016).

However, the primary reason the author chose Fallout 4 was to investigate if Bethesda had changed its modular process since Skyrim, as Fallout 4 was the next game after Skyrim. Additionally, the Fallout series is sci-fi themed instead of medieval fantasy. The author reasoned that analysing games with different themes could provide information if the theme has an impact on how modularity is utilized, since the games are otherwise quite similar. (Skyrim 2016.)

Like Skyrim, Fallout 4 features an open world that the player can explore. The world is based on real-world Boston and Commonwealth in North America, which gave the developers a problem to solve having to replicate a real-world location inside the game engine. The developers wished to make the connection between the real and in-game Boston evident. Therefore, several key locations and landscapes had to resemble those from real-life. (Burgess & Purkeypile 2016.)

A comparison of the game environments is shown in Figure 20. Skyrim is displayed in image A and Fallout 4 in image B. Compared to Skyrim, which is mostly northern wilderness and tundra, Boston features heavily built environments in addition to nuclear wastelands (Skyrim 2016).

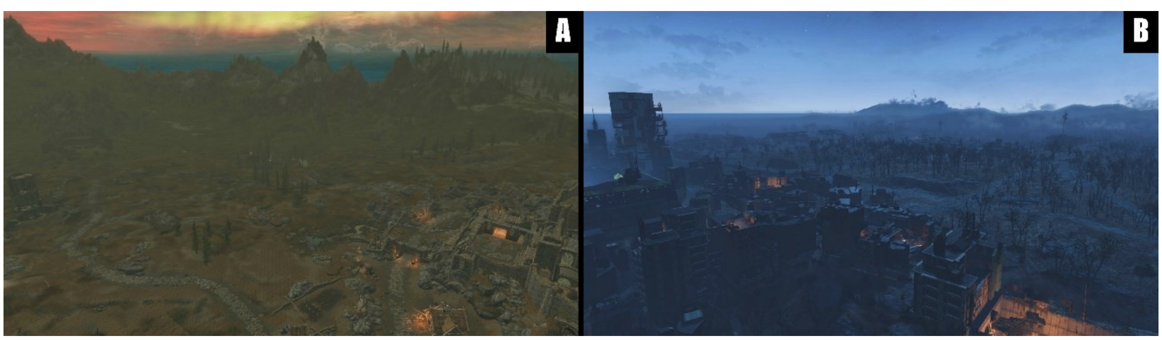

Figure 20. Worlds of Skyrim and Fallout 4 (Fallout 4 2015; Skyrim 2016)

Unlike Skyrim, Fallout 4 did not feature extensive faction-specific modular kit styles. However, the game features multiple different kits for a variety of different purposes. The author identified several functions for these kits: like Skyrim, there were modular kits for assembling building interiors and exteriors based on the theme of the building. In addition to this kind of modularity the author noted several utility kits that Bethesda combined with other modular building kits to create further variety through kit-bashing several kits together. (Skyrim 2016.)

Examples of the exterior building kits can be seen in Figure 21. The author identified six styles. However, these observations were based on around a quarter of the game world, which leads the author to believe that there are more. The kits that the author recorded were small personal detached houses (image A), apartment buildings (image B), scientific buildings (image C), industrial buildings and factories (imagine D), public service buildings like museums and town halls (image E) and military bunkers and checkpoints (image F).

Figure 21. Building Types (Fallout 4 2015)

Compared to Skyrim, Fallout 4 made more use of texture colour variations. Additionally, each modular kit had variety pieces in different stages of decay and destruction to further diversify the kits. Examples of how these texture colour differences, and modular variant pieces have been utilized by Bethesda are displayed in Figure 22. (Skyrim 2016.)

Figure 22. Building texture and damage variety (Fallout 4 2015)

Figure 22A showcases a wide screenshot of the city of Boston in Fallout 4 where most of the buildings are assembled from combinations of modular kits with varied texture colours. Image B is a close-up screenshot of a building where multiple broken wall variants are used to assemble a destroyed building. Kit-bashing with several modular kits, various variant pieces and varying texture colours allowed the developers to quickly create a vast city environment like Boston that is also performance-friendly (Burgess & Purkeypile 2016).

Like exteriors, Fallout 4 features a variety of styles of modular kits for building interiors. However, while the author calls them interior kits, these kits have been utilized by the developers in the outside world in addition to the separated interiors. Like the exterior kits, there are many different themes and while the author recorded six, they suspect that there are more. Examples of the ones the author identified are shown in Figure 23.

Figure 23. Fallout 4 interior modular kits (Fallout 4 2015)

Image A is from a scientific building, featuring fractured metal walls exposing industrial pipes and wires. Image B is from a factory, and the kit is commonly combined with a metal platform utility kit. Image C is from a metro where the tunnels are often combined with a pipe utility kit. Image D is from a Vault, which are often high-tech and in superior condition to the outside world. Image E is from a utilitarian-military bunker, featuring simple concrete rooms and corridors; these generally utilize modular pipes or metal scaffolds from the utility kits. Image F features an apartment interior, which was utilized inside a variety of different buildings, from personal detached houses to apartment building room interiors.

In addition to colour and variation pieces, Bethesda utilized a third method to create additional variety in their environments: utility kits (Burgess & Purkeypile 2016). Like other modular kits, the utility kits come in different themes, and range from sidewalks and roads to fences, scaffolding, both wooden and metal as well as industrial pipes. Examples of these utility kits can be seen in Figure 24.

Figure 24. Utility kits (Fallout 4 2015)

Image A displays a scaffolding kit that was utilized to build construction frames around buildings. Image B showcases a variety of different kinds of fences and walls that were used to block pathways or sight lines. Image C is an example of assembling buildings by utilizing industrial metal pipes and scaffolding with some unique assets, while image D features a modular kit for creating roads and sidewalks. Image E shows how modular air vents and fire escapes can be utilized with buildings to create building variety and potentially offer alternative movement paths. Image F is an example of improvised shelters built using wood and metal scaffolding utility kits around a canal-like structure.

The utility kits were commonly utilized with other modular kits to create additional details over the buildings or to blend multiple kits. They were also utilized both in the interiors and exteriors to vary the visual style and theme of each environment. These utility kits were not only visual, but occasionally they provided pathways and connections between two locations that wouldn’t normally be compatible with each other. For example, Figure 24A showcases a scaffolding assembled between two modular buildings that did not share a grid orientation.

4.4 Arkane Studios: Dishonored

The third game the author analysed was Dishonored from Arkane Studios. It was released in 2012 and like Bethesda, Arkane utilized modularity in their production and their development team was extensive. Compared to Skyrim and Fallout 4, Dishonored is visually different. The game features a stylized hand-painted look, which proves that modularity can be utilized with any visual style. Additionally, like Bethesda, Arkane has released production material allowing further insight into the game’s production. (Fallout 4 2015; Skyrim 2016.)

Similar to Fallout 4, Dishonored features a vast city with interiors, exteriors and walkways. However, unlike both Fallout 4 and Skyrim, Dishonored is only a partially open world. The player can choose their path within each city block, but they cannot leave the city limits. Instead, the player transfers between city districts and separate building levels. (Fallout 4 2015; Skyrim 2016.)

Dishonored made use of modularity in building components like walls and roofs, but also in secondary assets like pipes, grates and scaffolding. They also commonly utilized kit-bashing, material variations and decals to break the repetition. The author noted different modular kit styles depending on the type of buildings, like in Fallout 4. However, Dishonored created variety by changing materials between building styles. This technique was utilized particularly in building interiors, commonly denoting a difference in the apartment wealth. Some of these material variations can be seen in Figure 25. (Fallout 4 2015.)

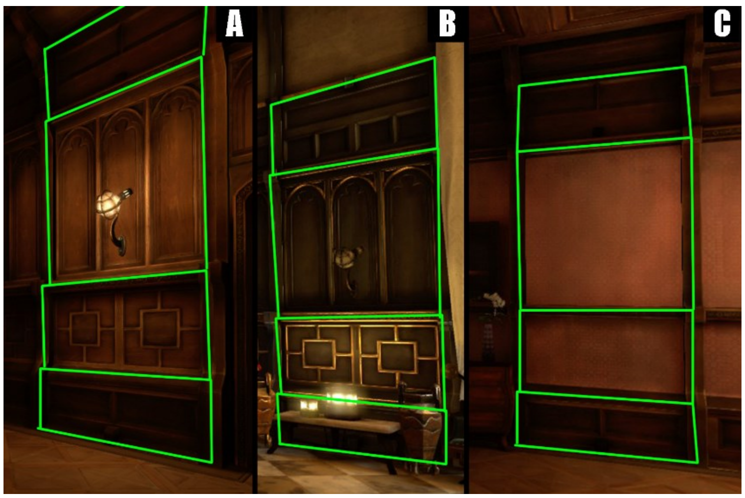

Figure 25. Dishonored Material Variants (Dishonored 2012)

Figure 25 contains three different wall materials found inside different buildings in the Dunwall where Dishonored takes place. In truth, the modular wall asset (highlighted in green) is identical in all three locations, but the developers have changed the associated material. In image A the player is in the hallway of a run-down house, while in image B they are in a well-kept and maintained apartment of a wealthy noble. Image C is from a bedroom of the same building as image B.

The 3D mesh of the asset is the same in all three walls, only the associated textures have been changed to create a different material. The similarity is the strongest between images A and B which likely share some of the texture maps like height, ambient occlusion or normal map. However, all three likely have a matching UV layout, allowing for interchangeable textures. This interchangeability is also present in building exteriors, some of which are shown in Figure 26.

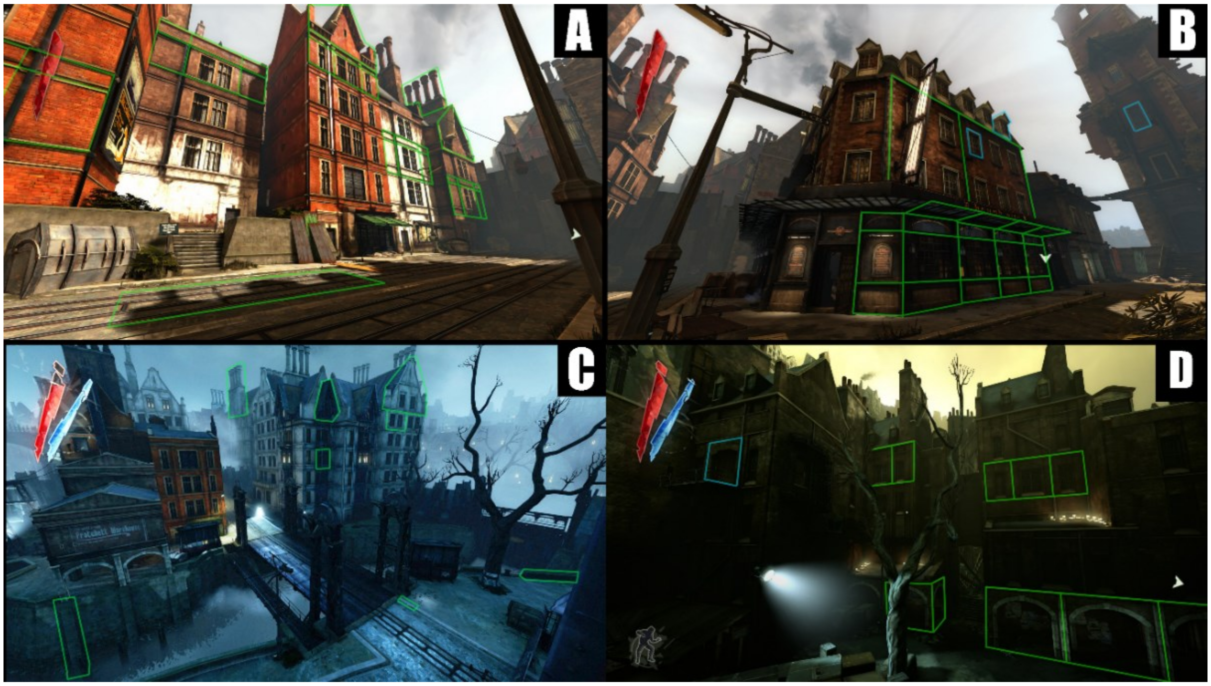

Figure 26. Dishonored building exteriors (Dishonored 2012)

Figure 26 contains several screenshots from Dishonored where the author identified modular assets being used to assemble building exteriors. The modular sections have been highlighted in green. Image A contains five buildings, each sharing similar walls and differing materials to create variety. Additionally, several of the walls have a matching outline, but the interior of the wall piece is different, these are likely variant pieces. In addition, the developers have utilized material blending in several buildings to create additional variety and the train tracks visible on the ground and the visible roof caps and chimneys are also modular.

Image B is of Hound Pit Pub, a unique building assembled from several modular pieces, which are highlighted in green. Additionally, the author believes that the 2nd floor and roof windows, which are highlighted in teal, are snap-on pieces added to the walls to assemble this building. A similar method has been used in the tower's windows. Image C contains several modular buildings that share the modular traits from image A. However, the author believes that the canal, road pavement, and walls in image C are also modular. Image D has repeating wall and arch sections highlighted in green and a variant doorway highlighted in teal that replaces the matching wall section of the green highlighted house walls, allowing entrance inside the building.

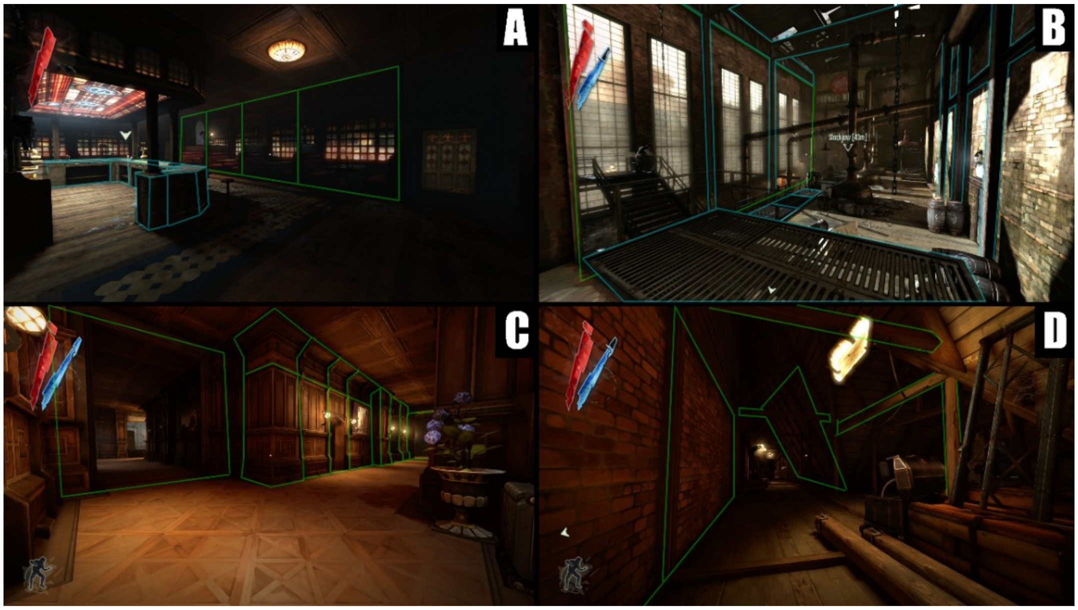

Figure 27. Dishonored interior modularity (Dishonored 2012)

Figure 27 contains images from four interior locations in Dunwall. Each of the images contains modular pieces which have been highlighted by the author. Image A is from the Hound Pit Pub, where the modular assets are the bar counter highlighted in teal and alcoves with chairs and tables in green. Image B is from Dunwall Whiskey Distillery, a distinctly different location, but which has likewise been assembled with modular assets. The repeating windowed walls are highlighted in green, and the metal supports and gantries are highlighted in teal.

Like the walls in image B, images C and D contain repeating wall assets. Image C is from a house corridor containing modular walls, doorways, pillars and alcoves highlighted in green. Image D is from an attic where the wall assets are combined with slanted roof pieces and wooden beams, which are highlighted in green. Additionally, the author believes that the brick wall material seen in images B and D is the same material with adjusted colour texture.

Figure 28 contains other applications of modularity in Dishonored. Image A contains a modular building in which components have been replaced with damaged variant assets resulting in a collapsed structure, these components are highlighted in green. Image B contains a warehouse built from modular wall assets that are combined with metal gantries and walkways to achieve an industrial warehouse theme. The modular sections are highlighted in green.

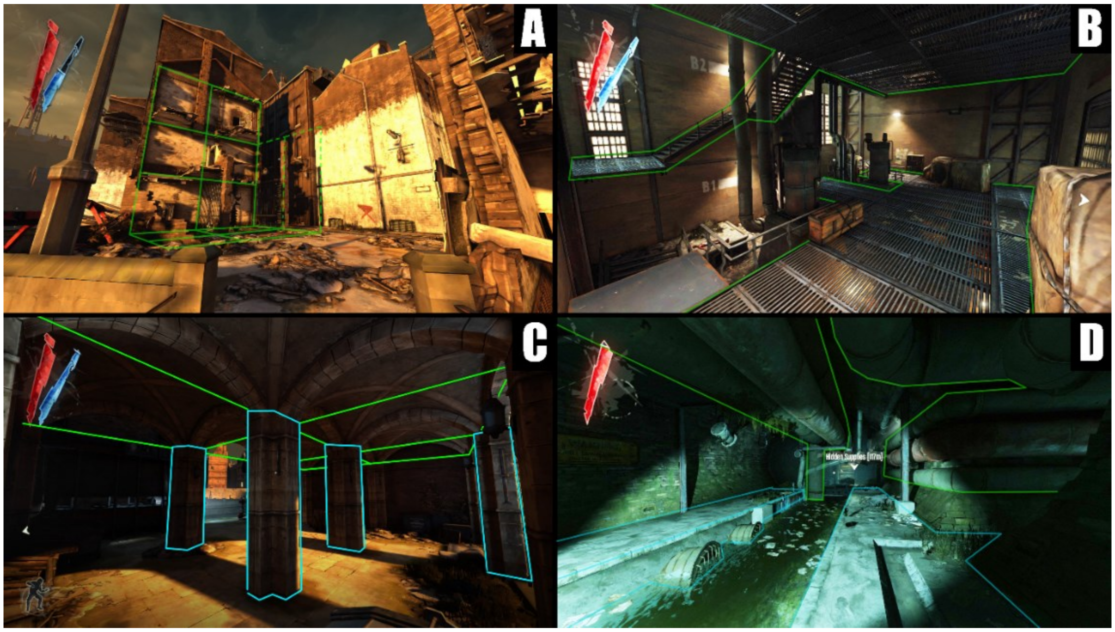

Figure 28. Dishonored additional modularity (Dishonored 2012)

Image C shows an application of arched roofs in green and pillars in teal to create an alternative building underside that is open to the exterior. Image D showcases modular pipes highlighted in green and sewer sidewalks highlighted in teal. The modular pipes and air ducts have been utilized extensively by the developers to provide the player with alternative movement pathways, additional examples of these traversable pipes can be seen in Figure 29.

Figure 29. Dishonored pipe pathways (Dishonored 2012)

5 INTERVIEWS

The information that the author gained from the history analysis is mostly from old video games. Therefore, alone it was not sufficient to provide an in-depth understanding of the current day 3D environment art. To provide up-to-date information and supplement the knowledge gained from the history analysis, the author interviewed professionals who are currently working within the industry as 3D environment artists. Interviews are a reliable way of acquiring qualitative information about the subject from professionals within the industry (Hennink et al. 2020; Hesse-Biber et al. 2011; Hirsjärvi et al. 2009).

The author interviewed individuals of different skill levels: a student, a senior and a lead, asking the same set of questions from all individuals. This allowed the author to analyse the answers and see if individuals of different skill levels provided similar answers. After the interviews, the results were analysed thematically by the author in combination with the results of the history analysis in Chapter 6, to provide a list of core concepts that the author utilized in the production of their case study in Chapter 7.

As a result of their initial research for the thesis and their previous experience from their education, the author formulated a hypothesis about the subject. 3D Environment Art is an integral part of game development, but the process is not simple, it is influenced by several aspects. While 3D environment artists are responsible for the creation of the game assets that are used to build the environments in which gameplay takes place, it is the level designers who design the layouts of these spaces.

The level designers design these game spaces based on the intended experience and gameplay requirements. The Environments must also visually match and support the game’s narrative, story and theme while also being technically feasible for the game engine to run at a smooth, steady frame rate without performance issues while maintaining a high visual quality. In addition, the production of these environment assets should be done within time limits set by the game’s production schedule and within allocated resources. This is something modularity assists with, by utilizing a modular workflow the environment artists and level designers can work simultaneously.

The author compiled questions based on the research questions for the interviewees to answer. The questions are divided into two categories, questions about teamwork and multi-person productions and 3D modularity in game production. The full list of questions is available in Appendix 1. The interviews were performed remotely through Microsoft Teams as online interviews, however, in one case the author emailed the list of questions for the interviewee to answer.

The interviews were recorded and transcribed. However, the interviewees requested that the recordings and transcriptions would not be included in the actual paper. Additionally, the names of each interviewee are omitted from the paper, as some of the interviewees wished to remain anonymous.

The author refers to these interviewees in alphabetical order when they refer to them in the text. First, the author introduces the interviewees, before summarizing the results of the interview results by topic rather than individual interviewee. Lastly, the author compares the interview results against the author's hypothesis.

5.1 Interviewees

The author reached out to several professionals for the interviews. However, due to time constraints and limited responses, the total number of interviews performed was limited to three. Nevertheless, these three individuals provide a wide experience range for qualitative results as they all represent a different seniority, and they all share experience as 3D environment artists.

Interviewee A is a senior student at a University of Applied Sciences. Before their current study, they have completed a game art degree in another school, totalling around five years of experience in terms of education 3D art. During the last couple of years, they have specialized in 3D environment art and realistic environments. They are also the founder of their school's 3D artists guild.

Interviewee B is currently working as a senior environment artist for a Finnish game company. Before their current role, they have five years of experience in the mobile games industry, roughly two years in triple-A production. In addition to experience in the game industry, they also have more than three years of experience in architectural visualizations.

Interviewee C is the Head of Environment Art for a Finnish game company working on PC and console games. They have over a decade of experience working in the video game industry, of which eight years are from their current employment. They are also an active mentor, who teaches students about 3D environment art.

5.2 Interview Results

The results of the interviews had a considerable amount of matching information and answers, particularly on the production side of the subject. However, the author noted that there are some differences in the interviewee's responses. These differences typically involve what topic the interviewee focused on and are likely caused by differences in the individual interviewee's working responsibilities and conditions, experience level and personal background and preferences.

While the interviewees' workdays vary by the nature of their seniority and backgrounds, they all mentioned the regularity of teamwork and collaborating with other employees. This included attending meetings, dividing work assignments and creating assets for other people or teams. How individual companies handle the collaboration varies, but interviewees B and C mentioned project management software, while interviewee A focused more on meetings.

Interviewees A and B mentioned a difference between working individually against working with a team. When creating personal or solo works, the artist has more freedom to make decisions. However, when working with a team, the artist is part of a pipeline that works towards the singular goal of creating the video game. As such while working the artist must consider other aspects of the development, this is something that was also mentioned by interviewee C.

Communication with other employees and teams was uniformly agreed upon by the interviewees as the key foundation that makes multi-person production possible. Communication includes giving and receiving regular feedback, iterating the design process with other relevant production team members and project planning. Interviewees A and B also highlighted the importance of soft skills as part of this communication.

All the interviewees mentioned that 3D environment art is connected to various areas of development. Particularly, level design and lighting teams are highlighted and the interviewees mentioned the influence of game design on the environments. Essentially, 3D environment artists must balance the visual quality of the game spaces with other metrics like game performance, gameplay requirements and technical requirements set by the software and technology.

The interviewees highlighted the primary benefit of multi-person production as overall production speed. Although, interviewee C noted that smaller production teams can make changes faster because larger production teams have a longer feedback loop due to more people involved in the process. However, the overall production speed and quality are increased due to the reduced need to redo assets because all teams were involved in the process from the beginning.

The interviewees agreed that the benefits of multi-person production are achieved when the process is not interrupted. They mentioned several methods to avoid these interruptions. Interviewees A and C highlighted planning, while interviewee B focused on compromise. Interviewees A and B also highlighted the importance of naming conventions and folder structures. Interviewees A and C mentioned the importance of avoiding bottlenecks in production by considering the requirements of the next team in the production chain.

All the interviewees have utilized modularity in their projects at some point, and interviewees A and C commented that every project they have participated in has had some form of modularity involved. The interviewees highlighted production speed as a benefit of utilizing 3D modularity. In addition to production speed, the interviewees mentioned other benefits from the use of modularity. Interviewees A and B highlighted optimization through memory budgets and GPU draw calls, while interviewee C highlighted asset consistency in productions with multiple employees and throughout locations that use the same modular kits.

Interviewees A and C also mentioned the benefits of 3D modularity towards level design. Modular blockout pieces enable level designers to work on their designs and map layouts, while the environment artists work on creating polished 3D assets. Interviewees B and C remarked that modular pieces enable people to work with levels inside the game engines instead of relying on 3D software to make modifications to the game environments.

Like multi-person productions, 3D modularity comes with several considerations. The interviewees mentioned the importance of pre-planning, modular assets pivot placements, grid, and object sizes. Interviewees B and C highlighted the importance of planning the kit in advance and testing it to determine if creating a modular kit is worth the time investment against using unique assets instead.

In some situations modular kits can be very complex to create and utilize, so it might be faster and easier to just use unique assets. Both B and C interviewees also mentioned that when creating a modular kit, it is important to remember that the modular kit is a tool that other people will utilize. As such, it should be easy to use, and it should come with documented instructions on how to use it. Lack of documentation can result in problems when people implement the kit incorrectly.

The primary disadvantage of using modular kits, according to all interviewees, is its repetitive nature and the initial time investment spent designing them. However, interviewee C noted that people expect a certain level of repetition in real-life environments, particularly in artificial locations. This provides some lenience towards the asset repetition. The interviewees mentioned several methods that can be utilized to hide this repetition.

All interviewees mentioned decals and material blending or blending modular assets with unique meshes, props and set dressing as effective methods of hiding the repetition. Interviewees A and C also mentioned using techniques to randomize content or textures. Essentially, any technique that allows the developer to make modular assets look like it is unique by hiding the repetition is useful if the technology in use allows it. Which methods are available to a developer varies by project and by game engine.

All three interviewees believed that 3D modularity will continue to be utilized by the industry due to the technique's significant effect on production speed and the possibilities it offers for level design. None of the interviewees could think of any way the workflow might be changed in the future. However, interviewee C noted that the technique might become even more relevant in the future with the advances in technology. Players expect higher visual quality from games, and modular workflow allows developers to speed up the production process of 3D assets to compensate for the higher expectations.

Interviewees A and B considered modular techniques extremely useful for 3D environment artist's and all the interviewees considered 3D modularity to be beneficial for multi-person pipelines. Mainly from the advantages it provides towards the level design process and game engine implementation. Interviewees B and C noted that 3D modularity should be considered case by case, and it might not be suited for all scenarios. Additionally, while interviewee C considered modularity a useful tool for 3D environment artists, they also noted that the technique is perhaps glorified to some extent.

As was mentioned in Chapter 5, the author had formulated a hypothesis about the subject. The interview results confirmed the author's hypothesis that 3D modularity is a useful method for game development, particularly a multi-person pipeline. Additionally, the answers confirmed that 3D environment art is a complicated process that involves several production teams and that the 3D environment artist must consider aspects of development from other production teams' perspectives and create the environment to match the requirements set by other teams. However, the author did not expect the answers to focus so much on the production speed benefits of the 3D modular workflow.

6 THEMATIC ANALYSIS

The author analysed the results of the interviews, the information gained from the base concepts and the history analysis. Since the information they received from their research is qualitative in nature, the author analysed it thematically. According to Caulfield (2023), thematic analysis is a useful approach to provide answers from qualitative data by identifying recurring themes.

Caulfield (2023) also points out that thematic analysis relies on the researcher's judgment and involves a risk of missing nuances in the data. However, this risk is diminished by the fact that the results of the author's research are based on multiple qualitative research methods and the author relies on information provided directly by the developers in addition to the author's observations. Additionally, the similarities in terminology and topics are considerable between the answers the author received during their research, further reducing the risk.

The author identified several recurring themes by using a combination of inductive and deductive approaches. As mentioned in Chapter 5 the author had formulated a hypothesis about the subject, which formed the deductive component. This hypothesis was confirmed by the interview results, allowing the author to utilize the deductive approach. However, the results of the interviews revealed a theme not included in the author's hypothesis. The author included this additional theme as the inductive component of the thematic analysis.

The themes that the author identified during the thematic analysis are displayed in Figure 30. The author established them by listing keywords selected from the history analysis and interviews, before categorizing them by topic and context. This enabled the author to identify the most common themes. The six identified themes are multi-person production, production structure and planning, production speed and quality, performance, optimization and technical limitations, techniques for avoiding negative effects and asset repetition and consistency.

Figure 30. Thematic analysis themes

The author compiled a list of core concepts from these themes to utilize during the production portion of their thesis in Chapter 7. Additionally, the author utilized these core concepts as foundations for their SWOT analysis in Chapter 7.5 by forming the evaluation criteria for the analysis. These core concepts are visualized through a mind map in Figure 31 in yellow. Each of these six concepts has several considerations that will influence the author’s work during this paper’s production phase. These considerations are marked in light green.

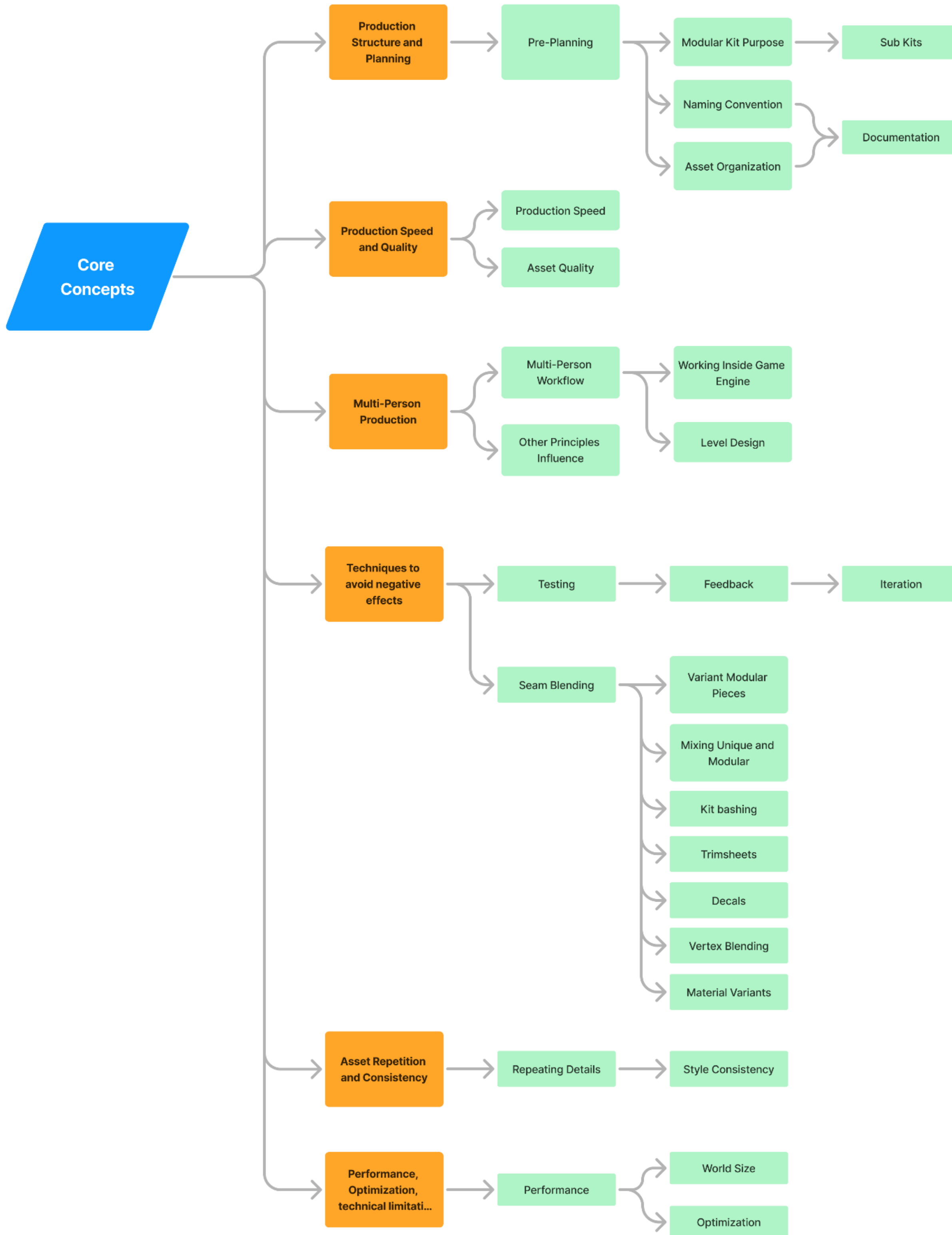

Figure 31. Thematic core concepts

The first concept involved production structure and planning, which meant that the author would have to design the modular kits, purpose and any potential sub-kits. Additionally, the author should consider a naming convention, how to organize the assets and document these details. The second concept involved production speed and quality, essentially the author should be able to produce several assets at decent quality and fast.

The third concept involved producing assets for a multi-person production. The author should consider other game design principles' influences on the 3D environment assets. In addition, the author should create the modular kit with a multi-person workflow in mind. First by creating the blockout assets which allow the level designer to work while the author creates the proper assets, these blockout assets should also be implemented inside the game engine.

The fourth concept that the author should consider is how to avoid the negative effects of modularity. The assets should be tested early, and the feedback received should be implemented. Preferably, the assets should be iterated multiple times. Additionally, the author should implement some form of seam blending methods to lower the negative effects of repetition.

The assets created by the author should also comply with the fifth concept, which means that they should contain repeating details and be visually consistent in style with one another. The final concept that the author must follow is technical limitations. The assets should be optimized to be performance-friendly in the context of the project when implemented within the game engine.

7 CASE STUDY

To accurately test the results of their research, the author implemented their findings in a game project that utilized a multi-person pipeline. This process is visualized in Figure 32. The project was split into four primary phases: Introduction (light blue background), Planning (orange background), Pre-production (dark blue background) and Production (purple background). The process additionally involved a repetitive iteration phase (yellow background).

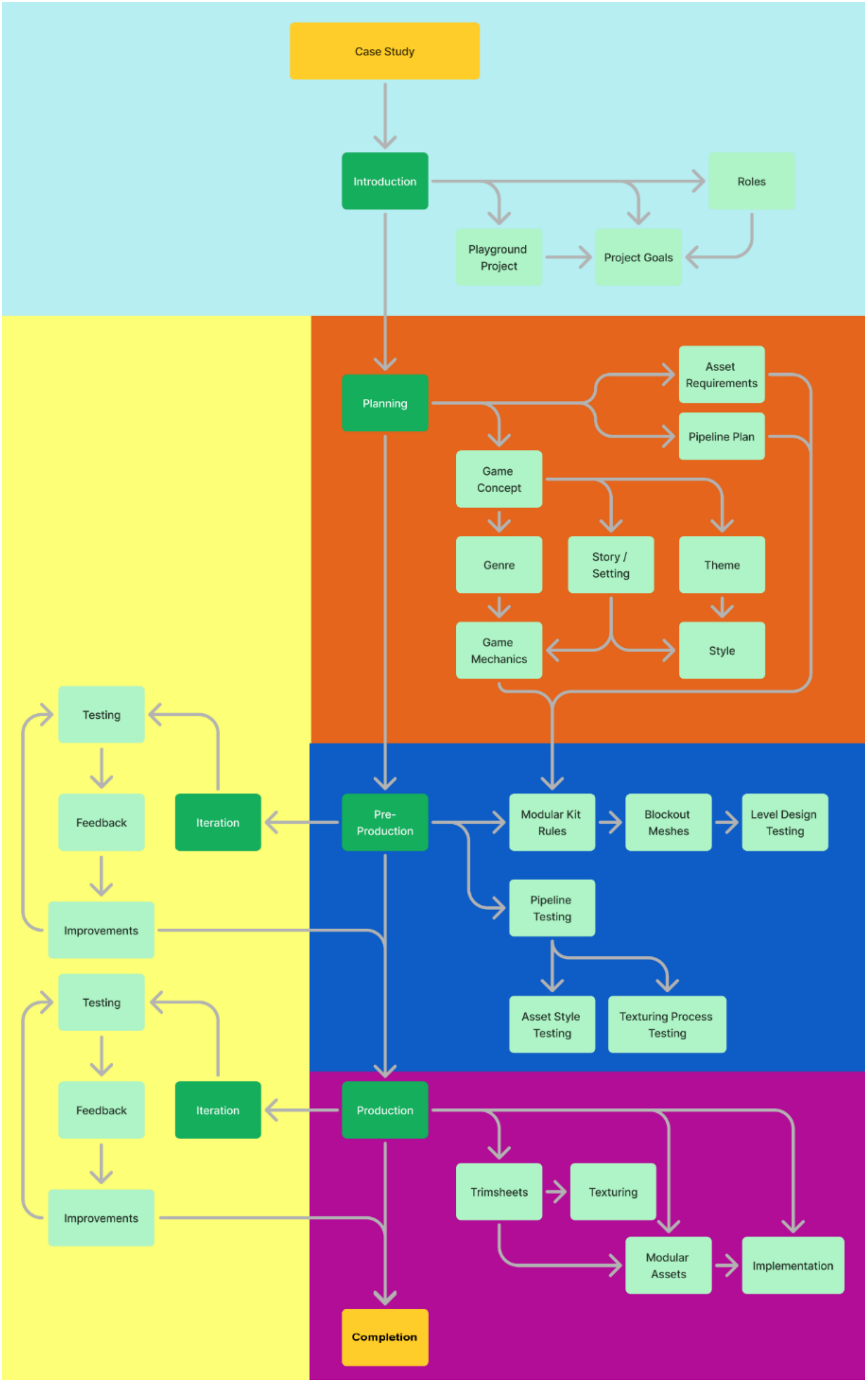

Figure 32. Case Study Framework

The author describes these phases in detail in chapters 7.1-7.5. The production was iterative and during development, the author iterated on the design of modular kits and trimsheets multiple times based on the feedback received from the texture artist and level designer (elements with yellow background in Figure 32). The author's hypothesis for the case study was that an environment artist could work simultaneously with a texture artist and a level designer, without any of these individuals bottlenecking the production process of other team members.

7.1 Introduction to the project

The case study project is called the Playground Project. The project features a small tech demo, where the owners of the project can practice and improve their skills freely without the pressure of outside influence. The Introduction portion of the case study can be seen in Figure 32 within the light blue background. In this chapter, the author introduces the reader to the premise of the playground game project by explaining the intentions and goals of the project.

During this case study, the author worked as an Environment Artist (EA) with two individuals functioning as a Level Designer (LD) and Texture Artist (TA) to test the modular workflow methods. The level designer in the project was Andreas Marcato and the texture artist was Jenna Toivonen. However, for the remainder of the paper, the author refers to these two individuals by their roles.

To test the modular workflow, the author was responsible for designing and creating the modular kits and trimsheets utilized in the game project. The TA was responsible for texturing these 3D assets and the trimsheets. The LD was responsible for designing the level layouts and testing the functionality of the modular kit. The goal of the playground project was a minimum viable project prototype with basic game mechanics and objectives. However, the author's goal during the production was to create a modular kit that is extendable for possible future applications.

Should the developers of the playground wish to continue the project further, the modular kit can be utilized to assemble additional environments for the game. Subsequently, this means that the author designed the modular kit as if it were being produced for an official game project. While the story and setting have not been defined at this stage, there is enough information and material available that allows the author to plan and design the modular kit.

7.2 Planning

During the planning phase, the author established rules and guidelines with the TA and LD regarding the modular kit. These rules include how the kit should look, function and how they should be made. Figure 33 showcases how the established game concept influenced the modular kit rules through the game's genre, story and theme.

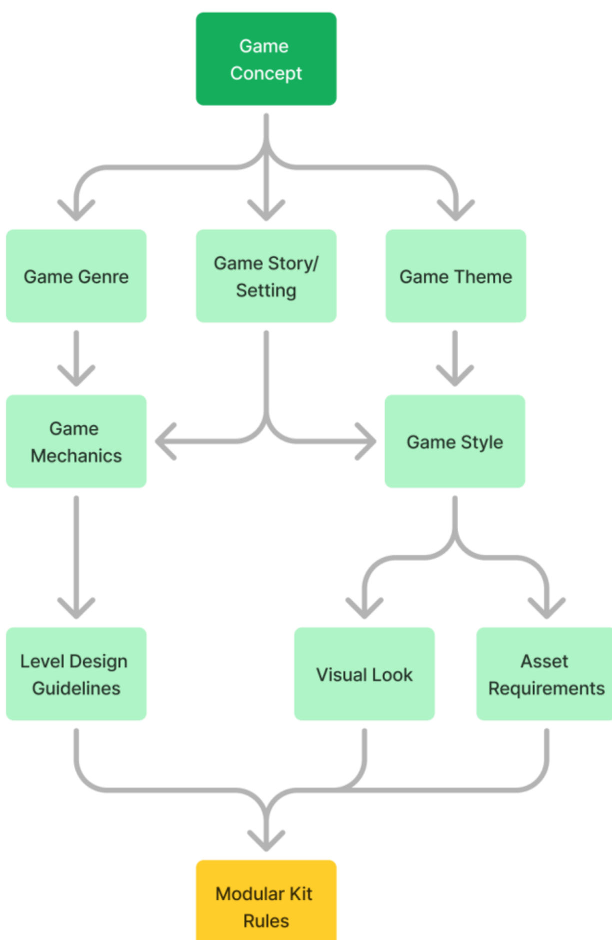

Figure 33. Playground mind map

> *Playground Project is an action-adventure game where the player controls an agile young boy hosting a wolf-like malevolent spirit entity, the game consists of the player exploring Tibetan ruins and fighting creatures that pose a threat to them (Playground GDD 2024)*

This game concept summary from the game design document (GDD) is quite vague to produce a full video game. However, for the purposes of the prototype and particularly the production of the modular kit, it provides enough background information to establish modular kit rules. The summarized portion of the GDD is available in Appendix 2.

Based on the summary from the GDD, the game genre is action-adventure. This, together with the game's story, determines the gameplay mechanics. The player controls an agile young boy who explores Tibetan ruins and fights creatures; together with the genre this establishes that the project's primary gameplay mechanics will be fighting, climbing and exploration. These mechanics then influence the level design requirements: the levels should be designed and built in such a way that promotes the player's ability to explore, climb and fight.

Essentially, the environments should be built in a way that allows the game's climbing system to function, while also clearly indicating to the player where the player can climb. The kit should allow the LD to design and build interesting and complex areas that promote exploration. Additionally, the kit should provide opportunities for building platforms and areas that are large enough to support a 3rd person fighting game.

The game has several animations that require a minimum space to play properly. Additionally, the player viewport (camera) is located behind the player's character, resulting in rooms and doors having to be slightly larger than they normally would be. The third-person aspect of the game allows the textures to be slightly less detailed than in a first-person game, as the player is incapable of observing the textures from up close.

In addition to showcasing the connection that game mechanics and level design have on environment assets, Figure 33 also shows how the game's story and theme establish the video game style. Video game style determines the game's visual look and establishes asset requirements. As mentioned in the concept summary, the player will be exploring Tibetan ruins, which determines how most of the environment should look like. Secondly, the developers decided that the game would be visually stylized, which sets certain environmental requirements.

Additionally, since the project's purpose is to improve the developers' personal skills, they aim to build the game as optimized as possible, to match the requirements of real game development. These considerations and discussions the author had with the TA and LD essentially set the following requirements: the game assets would be stylized, and the modular kit should be able to build ruins and platforms that can be assembled to promote exploration and climbing. Lastly, the assets should be as optimized as possible, meaning that the author should limit the number of materials and textures used by the modular kit assets.

7.3 Pre-Production

As part of the pre-production for the playground project, the author had two responsibilities related to their role as an EA. With the LD, the author was responsible for establishing a naming convention for the modular kit pieces to utilize, planning a functional footprint size for the modular kit in consideration of the gameplay. In addition to creating a simplified version of the modular kit to function as a blockout kit that the LD could use to start testing the functionality of the modular kit.

The blockout version of the modular kit was created with the ability to assemble floors, walls, pillars, roofs, stairs, and garden walls and with some variety pieces within each category. This blockout kit is shown in Figure 34 and the pieces were later utilized as a base template for creating the actual modular assets. Additionally, they could be utilized to create simplified colliders for the more detailed modular kit assets.

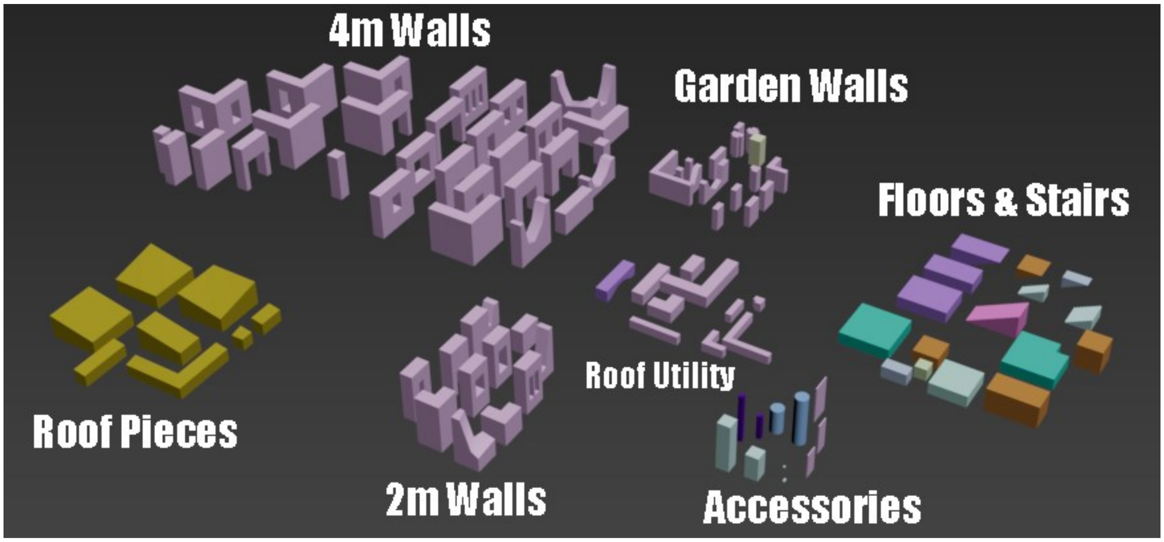

Figure 34. Modular blockout kit

All the blockout assets adhere to a 4 by 4-meter base grid, with a wall height of 4 meters. Some of the pieces have been created to accommodate a 2-meter variant size. An early decision was made by the group, that instead of pre-assembled modules, the modular kit would consist of individual granular modular sections that the LD could assemble as they choose inside the game engine. A visual example of this difference is shown in Figure 35: asset A is a traditional modular corner "module" while asset B is a combination of smaller individual granular modular components.

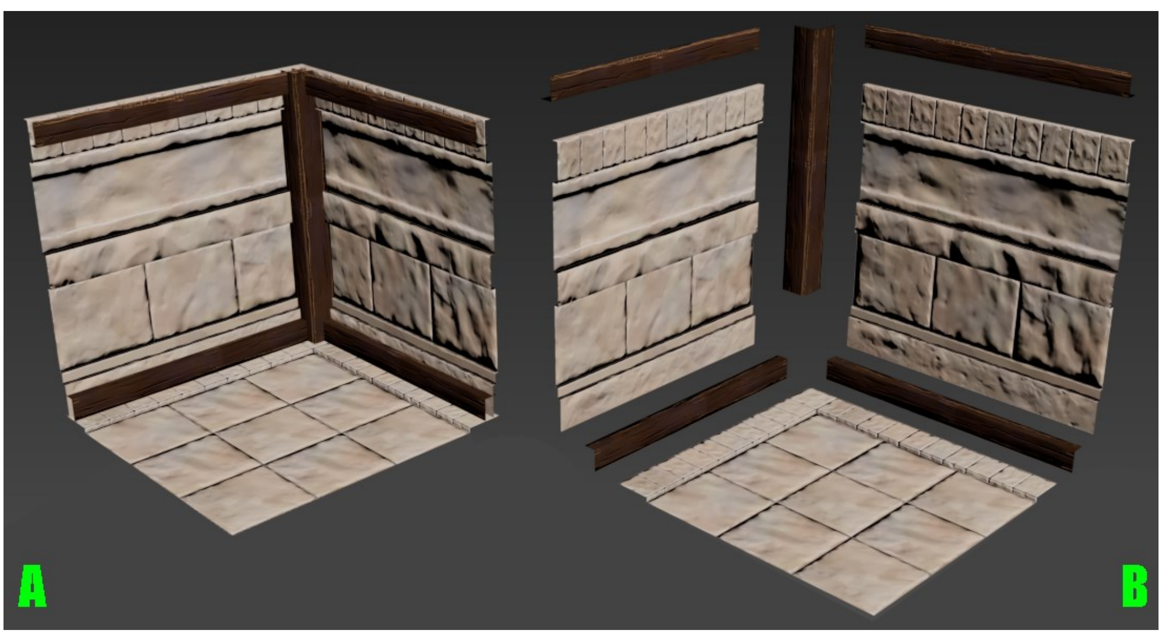

Figure 35 Granular modularity

The method of splitting the modular assets into smaller modular components that are granular limits the number of assets that the environment artist is required to create (Burgess & Purkeypile 2016). Initially, it might appear that the environment artist must create more pieces with the granular approach than with the traditional method. However, the granular method allows the LD to reuse the granular pieces inside the game engine, quickly assembling a variety of combinations.

The total number of assets in the kit reached 135 models. To assist with the identification of these objects and file organization, the LD and the author planned a naming convention. An example of this is MK_MNS_Wall_4m_00, which translates to Modular Kit_Monastery_Wall_4m_Variant 00. The format is Asset Group_Kit Group_Asset Type_ Asset Size_ Variant Number. A visual aid is provided in Figure 36 to help understand the abbreviations of the convention

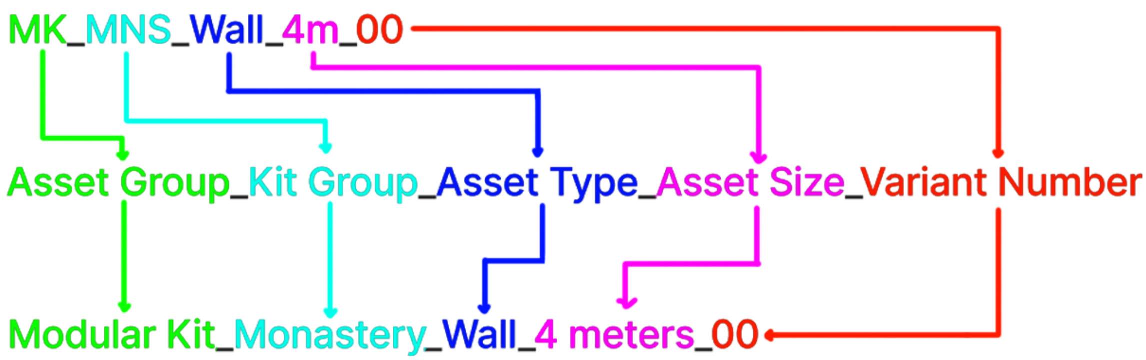

Figure 36. Playground naming convention

Based on the initial test results of the blockout kit performed by the LD, a few assets needed modifications by the EA. Some pivot placements were changed to match the personal preference of the LD, and a few additional floor pieces were created to better match the 4 by 4-meter footprint when assembling buildings with multiple floors. The most notable change from the first tests was changing how the roof modularity functions. Instead of providing roof components that already include the roof eaves, the eaves were separated from the mesh to provide more flexibility for the modular roof components and to better match the kit footprint. This change is visualized in Figure 37, the old pieces are shown in red and the new ones in green.

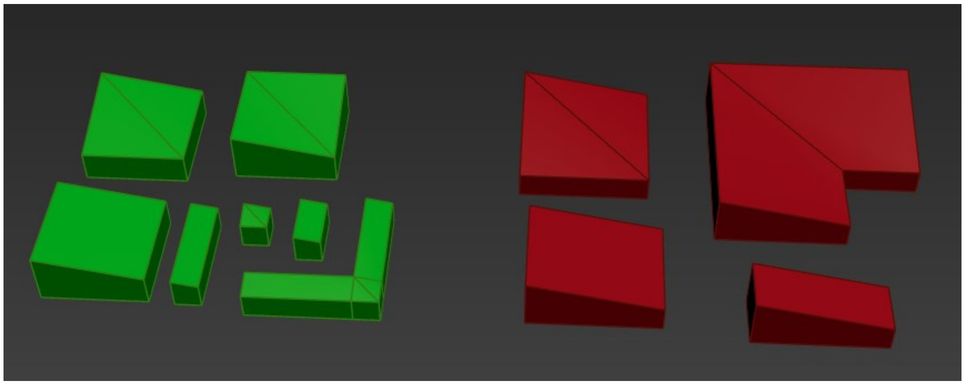

Figure 37. Modular blockout roof change

The problem with the first iteration was that the roofs did not match the footprint of the walls. The roof eaves did not fit inside the footprint, which caused problems when the roof was utilized in corners of the buildings, resulting in clipping. Splitting the eaves into separate components allows the LD to assemble the required roof component from smaller pieces, resulting in extra flexibility and preventing clipping. It also allows the EA the option to prepare more variant pieces in the future and makes assembling roofs easier for the LD by having better pivot point placements compared to the old one.

In addition to working with the LD to plan the guidelines for the technical aspects of the modular kit, the author worked together with the TA to establish the intended art style for the 3D assets. Additionally, the author and the TA designed the production pipeline which the author and TA would utilize in the production and agreed on the texture grid rules for trimsheets that would be created and utilized in the playground project.

To establish the art style, the author prepared two test 3D assets to trial the potential texturing pipeline. These tests can be seen in Figure 38, with image one showing the two low poly tests alongside the high poly sculpt and image two showing the mesh wireframes. The difference between the two test cubes A and B is the total number of vertices. The intended pipeline has the texture artist utilizing substance painter to bake normal maps from the high poly sculpts, before utilizing a smart material created in substance designer. The textured results of this trial can be seen in Figure 39, containing examples of both tests.

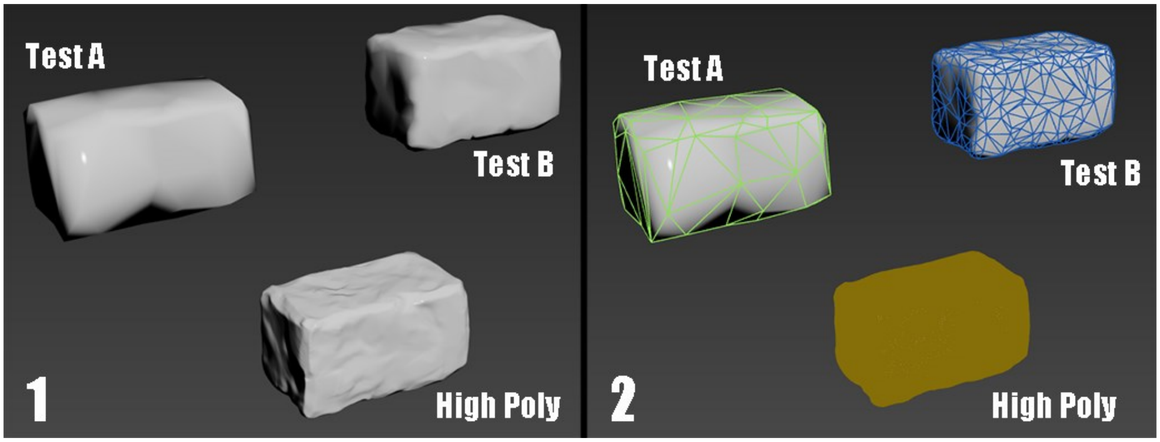

Figure 38. Playground test cubes

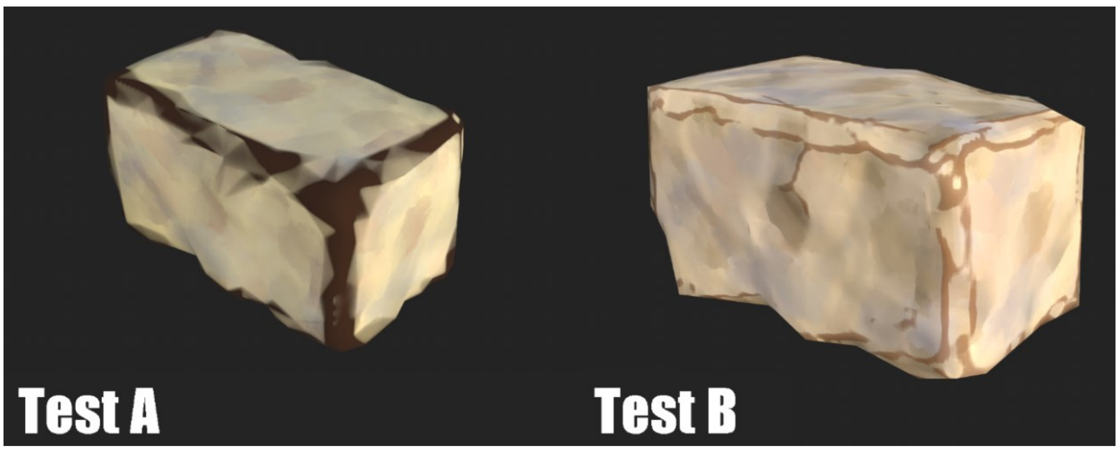

Figure 39. Playground test cubes textured (Toivonen 2024)

Based on the results of the initial test, style B was chosen. While style A contained fewer vertices, the results with the smart material were of higher quality with style B. The higher number of vertices provides better results with the normal map and curvature data, resulting in a higher quality stylized texture. The overall number of vertices is not an issue inside the engine as the increase was not considerable, and the assets will be utilized as static objects inside the engine.

Following the initial tests, the author created an asset with a bigger scale to test the visual look and intensity of the normal maps inside Unreal Engine, next to the player character. The results of this test can be seen in Figure 40. The wall asset incorporates the first iteration of the stone trimsheet which is one of the author's end goals for the project. Together with the TA, the author decided that the modular kit would be primarily textured with two trimsheets: wood and stone in combination with tiling textures.

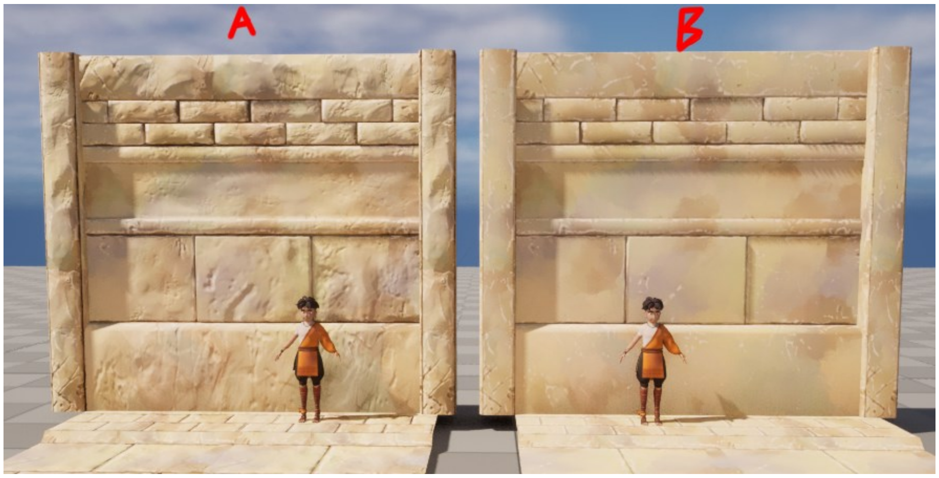

Figure 40. Normal map test

Figure 40 contains the same wall asset with two different materials. Test A utilized the normal map data from the high poly sculpt, while test B excluded the normal mapped data. The same test was also used to assess how the scale of the textures and the assets looked adjacent to the player character model. While the original intention of the project was not to utilize normal maps, test B was considered too simple and test A too detailed. As a result, the decision was made for the final textures to utilize normal maps but exclude small-scaled normal details. A highlight of this is shown in Figure 41.

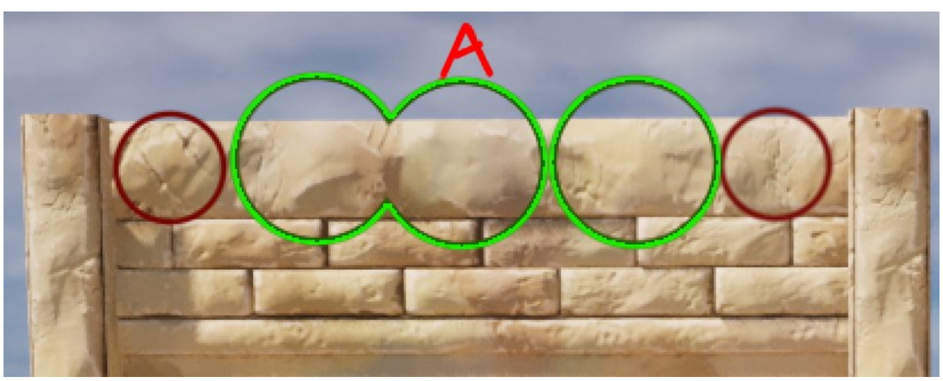

Figure 41. Normal map details

The final style utilized normal map data from the high poly models, but the details were limited to big forms (circled green). The small-scaled normal details were excluded from the high poly sculpt (encircled red). Utilizing the normal maps this way, allowed the assets to benefit from the high poly sculpt more than only by utilizing them to texture the assets through curvature maps.

7.4 Production

After the initial tests were performed and decisions were made regarding the final style and asset requirements, the author began the production process. The production was done simultaneously, with the LD testing the modular blockout pieces while the author created the high poly 3D assets. These high poly 3D models would be utilized by the TA to bake the high poly details required for the creation of the trimsheets during the texturing process.

To create the high poly 3D models that the TA needed, the author first created simplified block-out shapes in 3Dsmax for both trimsheets, which they then exported to Zbrush for 3D sculpting. Figure 42 shows the initial block shapes in image A, while image B contains the final high poly sculpts. The block-out assets functioned as a template from which the author could start sculpting, and they also provided a scale that the author could follow while working to prevent themselves from sculpting too far off from the original asset size.

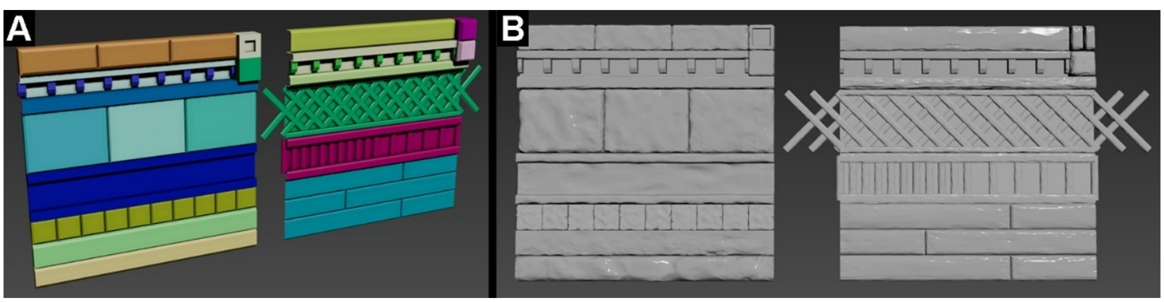

Figure 42. Blockout shapes to High poly

The process of creating these trimsheets was iterative between the TA and the author. The primary changes that were done based on this iteration process were modifications done to the trimsheet layout, proportions and the style of individual trimsheet components. During this process, the author created multiple variations of the trimsheet assets. Examples of these iterations are shown in Figure 43. A images contain iterations of the stone trimsheet while B images contain iterations of the wood trimsheet. The images are also numbered chronologically, with images A1 and B1 being the first iterations done during the production, while A2 and B2 are the second iterations and A3 and B3 showcase the final versions of the trimsheets.

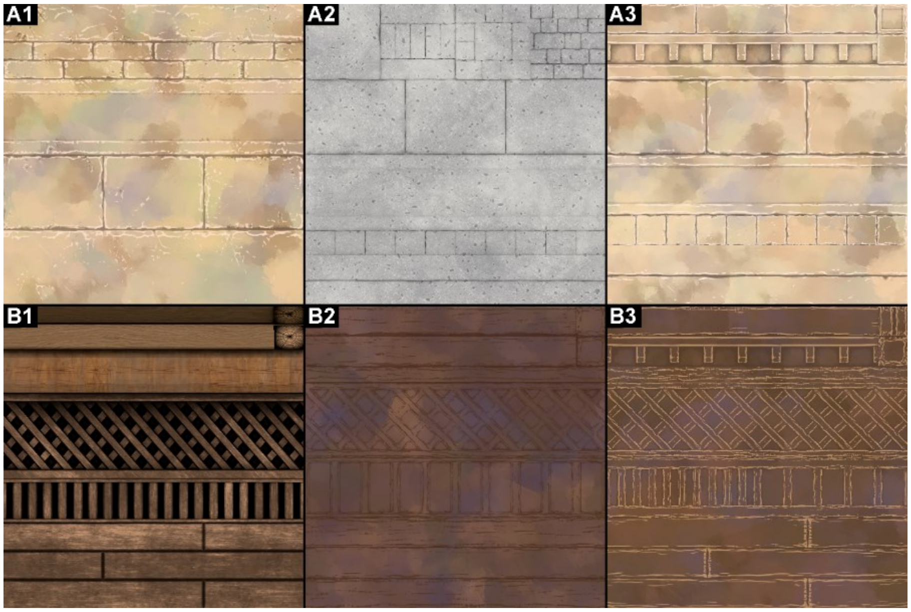

Figure 43. Trimsheet iterations

An example of the changes between the versions can be seen in image A2's top quarter, where four tiling textures were replaced with three stone strips and two cap assets shown in the top quarter of image A3. Additionally, the bottom quarter of the texture was modified to contain three trim textures instead of one smooth stone texture. This new layout arrangement matched the UV layout of the wooden trimsheet, which made the two textures interchangeable with each other.

Essentially, the trimsheets were changed to match a grid between the textures. This grid is shown in Figure 44, marked with blue lines. This matching UV layout allows the author to change between the two materials without additional modifications to the asset's 3D mesh or UV unwrap. Additionally, any future texture variants that follow this same grid can be utilized directly with any of the 3D assets that are unwrapped to match this specific layout.

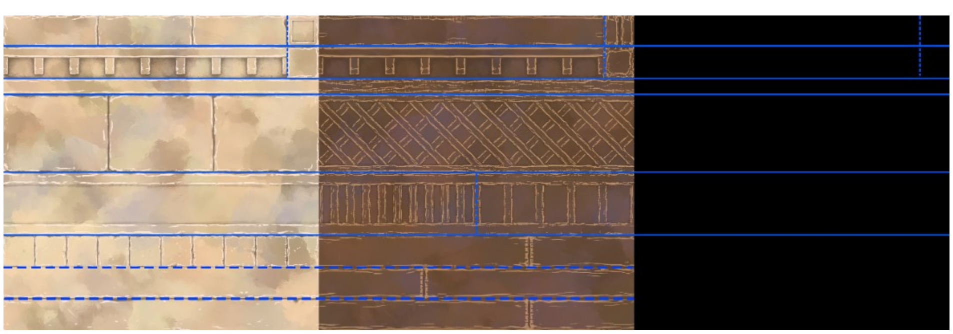

Figure 44. Trimsheet grid

With the created trimsheets ready and textured, the author began the process of creating the modular kit assets that would replace the modular blockout pieces. The author worked in 3Dsmax, using the initial blockout pieces as base templates and as footprints for the more detailed 3D assets. An example of this process is shown in Figure 45, with five in-progress images.

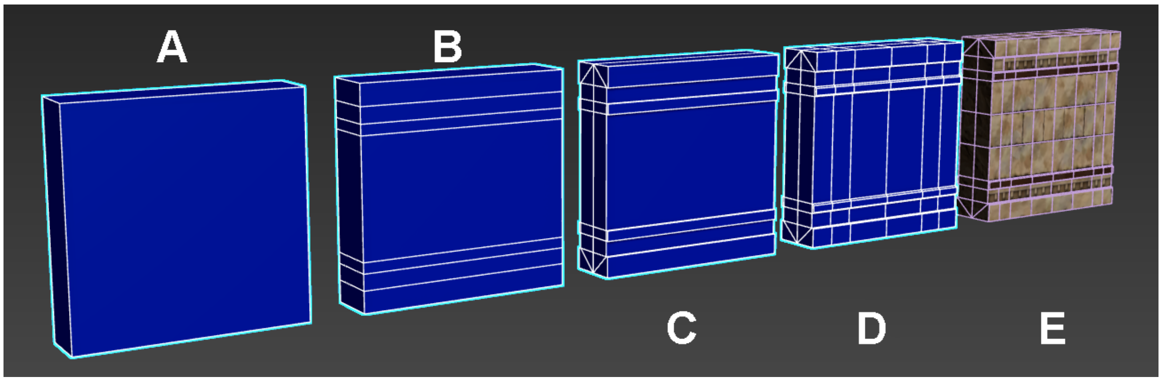

Figure 45. 3D asset workflow

The author modified the basic blockout piece for a 4m wall asset (Figure 45A) by utilizing edge loops to divide the model into sections that they then modified further (Figure 45B). The sections created by the edge loops were extruded inward giving the asset depth and surface (Figure 45C), which the author then chamfered to give the mesh a more detailed look (Figure 45D). At this stage, the author applied the trimsheet materials onto the mesh and UV unwrapped the surfaces to match the trimsheet layout (Figure 45E). To match the modular kit footprint, the detailed 3D mesh had to fit inside the original blockout mesh, which could be used to confirm this by overlaying it with the detailed mesh.

This modelling process was repeated for all the modular kit pieces. While the author was modelling these assets, the LD gave feedback based on their tests that several components were needed to complete the modular kit's functionality. During the initial design the author had overlooked a few assets, but with their completion, the entirety of the version one modular kit was built. These assets are shown implemented inside Unreal Engine 5 in Figure 46, totalling 135 modular 3D assets, two trimsheets and two tiling materials.

Figure 46. V1 modular kit

However, it should be noted that this bundle is only the first iteration of this modular kit. Environment Artists typically work in passes, which means that environment production is completed through several portions. In this first iteration, the author converted the blockout mesh into more complex 3D shapes and applied the trimsheet materials to them. (Burgess 2014; Burgess & Purkeypile 2016; Salmond 2021; Watkins 2011.) The next passes would include further details on the models: additional mesh complexity, include tiling materials instead of only relying on the trimsheets, implement vertex colours and texture blending in addition to modeling additional variant pieces. However, for the scope of this thesis and the given timeframe, the extra passes were excluded.

7.5 SWOT Analysis

The author analysed the outcomes of their production by utilizing a SWOT analysis. The criteria were focused on the qualitative statistics: overall quality of the 3D assets (polycount and texel density), hours spent on production and how well the modular pipeline functioned with the multi-person production. Additionally, the SWOT analysis utilized the core concepts identified by the author during their thematic analysis in Chapter 6. The author used these six concepts as a criterion to analyse how successful their production was. This was done by analysing the product and considering the production cycle against the core concepts and the related considerations.

The results of the SWOT analysis are shown in Figure 47. Each colour represents one of the core concepts. Blue for production structure and planning, orange for production speed and quality, purple for multi-person production, green for techniques to avoid negative effects, red for asset repetition and consistency and yellow for performance, optimization and technical limitations.

Figure 47. SWOT analysis

The strengths of the author’s production revolved around the plan and design process, which was done in cooperation with the TA and LD. The modular kit has a clear naming convention and folder structure, which were established at the beginning of the project by the whole team. Overall, the kit was designed from the very beginning with the game concept and its requirements in mind. The design of the trimsheets was also influenced by the intended style and theme of the game. Additionally, the author considered optimization from the very beginning of the project when creating the assets and materials.

However, the project has several weaknesses imposed by time limitations. The trimsheets created by the author are not entirely interchangeable due to a design flaw, and the assets of the first iteration of the modular kit do not incorporate tiling materials. Additionally, the time limitations prevented the author from incorporating any seam-hiding methods at this stage of the development and from preparing any proper documentation.

However, the first iteration of the modular kit does contain several opportunities. The kit footprint is designed to match a grid that follows the power of two size, and it already contains kit bashing potential and multiple functional trimsheets. The level designer can implement and test their levels with the available assets that are implemented and usable inside the game engine.

The asset materials are also set-up with a singular master material and material instancing, making future editions easy to achieve. Additionally, the project has a clear artistic vision, and an efficient texture pipeline has been established by the author and the TA, who also have several potential seam hiding methods already planned and prepared for.

The main threats to production are structural design problems, which originate from the early stages. The blockout kit was tested a limited amount of time, and the overall amount of feedback and iteration cycles during production was few. Additionally, the climbing system the game will utilize is due to be redesigned. This may cause changes in environmental requirements. Lastly, the author has limited experience with Unreal Engine 5 and the other developers had a limited amount of time for the project, which currently has resulted in the visual implementation to be ahead of the other departments.

An additional consideration the author wished to highlight is the modular kit itself. The kit was designed to be granular, which enables flexibility during use but does make the kit require more work during assembly. All the assets in the kit are consistent in style and materials, which is a strength and weakness at the same time. The first iteration of the modular kit relies heavily on symmetry and mirror modifiers, which have resulted in obvious repetition of the textures and meshes. However, the first iteration assets are low poly, and this makes them an efficient template for future iteration of the modular kit.

In total during the production, the author created two trimsheets, two tiling materials and 135 modular assets. The author spent around 60 hours iterating the trimsheet assets, 16 hours creating the blockout pieces, and 40 hours creating the first iteration of the modular kit. However, it should be noted that the hour account is not 100% accurate, as the author occasionally forgot to mark the hours and the production took place over several months.

The modular kit contains seven individual sub-kits, which are floor, garden, pillar, roof, utility, two- and four-meter wall kits. These kits can be utilized to assemble a variety of ruined buildings, gardens and rooftops. A detailed chart of the 3D assets is available in Appendix 3, which displays the statistics of each asset. This chart also lists all the modular components in the kits, their names, the asset and kit types, their physical size and the number of materials in each asset.

In total, the 3D environment assets currently utilize five materials: stone- and wood trimsheet materials, utility items material, broken stone- and terracotta materials. Each of these materials utilizes three texture files: base colour, normal map, and channel-packed ORM map (occlusion, roughness and metal). The final textures are shown in Appendix 4.

The trimsheets and utility kit texture sizes are 2048x2048 pixels, while the tiling materials utilize smaller texture sizes. The broken stone is a 1024x1024 and the terracotta material uses a 512x512 pixel ratio. The texture plan was to utilize a 2k texture on a 4m object, resulting in a texel density of approximately 512px/m (or 5,12px/cm), which according to Dries (2023) is a reasonable amount for a third-person video game. However, due to the nature of trimsheets the actual texel density of each object varies.

The multi-person pipeline functioned successfully during the production. The author created the blockout meshes early, which enabled the level designer to start assembling the game environments. Some applications of the modular kit are shown in Appendix 5. These blockout pieces were replaced as the author finished modelling the proper assets. Some modifications were required with some of the assets as the level designer requested changes to their pivot points. However, the influence of this change was minimal.

The texturing pipeline functioned without issues after the iteration process was finished. Any modifications done to the textures will instantly work within the game engine if they adhere to the trimsheet rules. However, the mesh UVs are not entirely interchangeable resulting from a trimsheet design flaw, but this is rectifiable in the future iterations of the modular assets. Regardless, the pipeline is effective and fast at providing optimized results.

Overall, the developers of the playground project are satisfied with the visual quality reached during this stage of development. However, it should be noted that the modular kit was not implemented at a functional game level and the process of creating a finalized modular kit requires further iterations and additional detail, as well as the inclusion of seam blending methods. However, these are beyond the scope of this thesis within the available timeframe.

8 CONCLUSIONS

The intention of this thesis was to investigate the effects of 3D modularity in multi-person production pipelines. To facilitate this, the author first introduced the thesis subject and the related topics in chapter one. After the introduction, the author described the thesis framework and the thesis structure in chapter two. Following the introduction and thesis structure, the author provided the necessary base information that must be understood to utilize modular 3D pipeline and how these base topics connect to and are related to modularity in chapter three.

The introductory portion of the thesis was followed by the research phase, where the author performed history analysis in chapter four and interviews in chapter five. During the history analysis, the author analysed three video games that had utilized modular methods in their production pipelines and provided a short history of modularity in video games. While the analysed games were old, their information was supplemented with the information gained from the interviews.

The author interviewed three professionals working with 3D environments. They were chosen from different experience levels to assess whether they all provide the same answers. One of the interviewees was a senior student, another a senior 3D environment artist, and the last one was head of environment art. However, the quality of the interviews would have been higher if the author had secured interviews with multiple individuals of the same experience levels for cross-comparisons. In addition, interviewing level designers would have provided an alternative point of view on the subject.

The results of the history analysis and interviews were then analysed thematically in chapter six to identify recurring themes. These themes were used by the author to compile a list of core concepts, that they would utilize as a basis for their case study. Additionally, the core concepts would form the criteria that the production results of the case study would be analysed against.

Chapter seven covers the production portion of the thesis, where the author introduces the project before describing each portion of the production in detail. These portions were planning, pre-production, production and a SWOT analysis. During the case study, the author implemented the information they gained throughout the introduction and research portions of the thesis. This information was applied in the planning, design and creation of a 3D modular kit for the playground project in cooperation with a level designer and a texture artist.

The author created two trimsheets, two tiling materials and a 3D modular kit composed of seven sub-kits for the purpose of assembling environments for the playground game project. The production of these assets was iterative together with the level designer and texture artist. The results were analysed with the

SWOT methodology. Overall, the author is satisfied with the results of the production. However, there are some considerations the author wishes to note.

The overall quality of the production was affected by time limitations. While the author was able to iterate the design, planning and pre-production portions of the case study, the results of the production were limited to a single iteration. Additionally, the level designer and texture artist had limited time available to commit to the production during the time of the writing.

Notably, the planned changes to the climbing system may result in considerable changes to the modular kit. However, the production of the playground project continues outside the bounds of this thesis and the assets that were created for the first iteration of the modular kit are low poly, making them easy to modify further. Additionally, the development team has plans to implement seam blending methods with more detailed environments, and these plans are already considered in the design of the modular kit.

Regardless of the limitations and the quality of the production phase, the author gained enough information to answer their research questions. 3D modularity is a useful method for game developers to utilize during production. Game development is a complicated process, which commonly involves multiple people. As such, most if not all game development involves a multi-person pipeline. Developers strive to be as efficient as possible with the resources at their disposal, and time is one of the critical considerations for development.

Modularity can be utilized by game developers to provide a variety of benefits for production. Overall, it speeds up the production speed, provides some technical performance benefits and consistency, and enables 3D artists and level designers to function simultaneously. However, modularity requires constant communication, planning and iteration between the involved parties. Additionally, creating a modular kit requires a higher initial time investment than creating a few unique assets, and it comes with limitations on how it can be employed.

Modularity is not a correct solution to all situations; developers should consider if going modular is the correct answer to their problem. Additionally, when modularity is utilized, the developers should consider how to reduce the negative effects of modularity, which is the obvious repetition. Like modularity itself, how this repetition is avoided depends on the project. The technology utilized by the developers defines which methods they can employ.

Modularity is a system that the developers can use. However, its overall effectiveness is defined by how well the system is planned and implemented. When developers utilize modularity, they must understand that it sets restrictions on how it can be used. If those restrictions are not followed, the system cannot provide the full benefits, and the results will be of lower quality. Ultimately, the effectiveness of the modular 3D methods is defined case by case and is influenced by the way it was designed and implemented during production.

REFERENCES

Ahearn, L. 2016. 3D Game Textures, Create professional game art using photoshop. 4th Edition. Boca Raton: CRC Press.

Ahearn, L. 2017. 3D Game Environments create professional 3D Game Worlds. 2nd Edition. Boca Raton: CRC Press.

Arellano, J. 2024. Creating Modular Kits for Game Environments with Jon Arellano. Beyond Extent. Youtube. Video Clip. 12 March 2024. Available at: https://www.youtube.com/watch?v=RKUPgY1fx1k [Accessed 24 October 2024].

Arkane Studios. 2012. Dishonored. Video game. Rockville: Bethesda Softworks.

Bethesda Game Studios. 2015. Fallout 4. Video game. Rockville: Bethesda Softworks.

Bethesda Game Studios. 2016. The Elder Scrolls V: Skyrim (Special Edition). Video game. Rockville: Bethesda Softworks.

Burgess, J. 2013. Skyrim's Modular Approach to Level Design. Blog. 26 March 2013. Available at: http://blog.joelburgess.com/2013/04/skyrims-modular-level-design-gdc-2013.html [Accessed 13 October 2024].

Burgess, J. 2014. The Iterative Level Design Process Used to Ship Fallout 3 and Skyrim. Blog. 22 May 2014. Available at: http://blog.joelburgess.com/2014/07/gdc-2014-transcript-iterative-level.html [Accessed 13 October 2024].

Burgess, J & Purkeypile, N. 2016. Fallout 4's Modular Level Design. GDC Vault. March 2016. Available at: https://gdcvault.com/play/1023202/-Fallout-4-s-Modular [Accessed 18 October 2024].

Burns, S. 2023. Trimsheets. Web page. Available at: https://www.beyondextent.com/deep-dives/trimsheets [Accessed 23 October 2024].

Caulfield, J. 2023. How to do Thematic Analysis, Step-by-Step Guide & Examples. Web page. Available at: https://www.scribbr.com/methodology/thematic-analysis/ [Accessed 7 November 2024].

Dries, T. 2023. Texel Density. Web page. Available at: https://www.beyondextent.com/deep-dives/deepdive-texeldensity [Accessed 25 October 2024].

Estrallado, J. 2024. Modular Doodling!. Twitch. Stream Recording. 16 September 2024. Available at: https://www.twitch.tv/videos/2252717103 [Accessed 25 October 2024].

Gahan, A. 2011. 3ds Max Modeling for Games. 2nd Edition. Oxfordshire: Routledge.

Hennink, M., Hutter, I. & Bailey, A. 2020. Qualitative Research Methods. 2nd Edition. Thousand Oaks: SAGE Publications Inc.

Hesse-Biber, S. & Leavy, P. 2011. The Practice of Qualitative Research. 2nd Edition. Thousand Oaks: SAGE Publications Inc.

Hirsjärvi, S., Remes, P. & Sajavaara, P. 2009. Tutki ja Kirjoita. 15th Edition. Helsinki: Tammi.

Hutchison, A. 2008. Making the Water Move: Techno-Historic Limits in the Game Aesthetics of Myst and Doom. *Game Studies*, September 2008. E-journal. Available at: https://gamestudies.org/0801/articles/hutch [Accessed 10 October 2024].

iD Software. 1993. Doom. Video game. Richardson: iD Software.

Kennedy, S. 2013. How to become a video game artist. New York City: Watson-Guptill.

Kronenberger, L. 2020. Balancing Modularity and Uniqueness in Environment Art. Web page. Available at: https://www.beyondextent.com/articles/balancing-modularity-and-uniqueness-in-environment-art [Accessed 21 October 2024].

McCombes, S. 2019. What is a Case Study? Definitions, Examples & Methods. Web page. Available at: https://www.scribbr.com/methodology/case-study/ [Accessed 11 November 2024].

McSherry, E. 2024. The Different Types of Trim Sheets & How They Are Used In Games (Part 1). YouTube. Video. 6 September 2024. Available at: https://www.youtube.com/watch?v=Y4cZbi8Mvxg [Accessed 24 October 2024].

Norris, J. 2016. Modular Building – Breakdown. Web page. Available at: https://www.purepolygons.com/blog/modular-building-breakdown [Accessed 24 October 2024].

Perry, L. 2002. Modular Level and Component Design. PDF document. Available at: https://docs.unrealengine.com/udk/Three/rsrc/Three/ModularLevelDesign/ModularLevelDesign.pdf [Accessed 10 October 2024].

Raeburn, A. 2024. SWOT analysis: examples and templates. Web page. Available at: https://asana.com/resources/swot-analysis [Accessed 11 November 2024].

Reveron, A. 2020. Procedural environment with Houdini and Unreal Engine 4. Web page. Available at: https://reveron3d.com/portfolio/procedural-environment-houdini-unreal-engine4/ [Accessed 11 November 2024].

Salmond, M. 2021. Video Game Level Design, How to create video games with emotion, interaction and engagement. London: Bloomsbury Academic.

Simpson, T. 2019. Trim Texture Tutorial. YouTube. Video. 12 April 2019. Available at: https://www.youtube.com/watch?v=IziIY674NAw&t=699s [Accessed 25 October 2024].

Stoneham, B. 2010. How to Create Fantasy Art for Video Games. London: A&C Black Publishers

The Investopedia Team. 2024. Bottleneck: A Point of Congestion in Production System. Investopedia. Web Page. Available: https://www.investopedia.com/terms/b/bottleneck.asp#:~:text=A%20bottleneck%20is%20a%20point,delays%20and%20higher%20production%20costs. [Accessed 11 October 2024].

Thorn, A. 2013. Game Development Principles. Andover: Cengage.

Thorn, A. 2014. Practical Game Development with Unity and Blender. Andover: Cengage.

Totten, C. 2014. An Architectural Approach to Level Design. Boca Raton: CRC Press.

Watkins, A. 2011. Creating Games with Unity and Maya: How to Develop Fun and Marketable 3D Games. Milton Park: Routledge

Zenimax. 2019. Level Architect job posting. Web page. Available at: https://gamejobs.co/Level-Architect-at-Arkane-Studios [Accessed 10 October 2024].

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Appendix 1

Interview Questions

1. Are you ok that the interview will be recorded and transcribed?
   - Do you want a copy of this recording and transcription?
2. Do you wish to remain anonymous (if so, skip question 3)?
3. Introduce yourself briefly, who are you?
4. What is your work experience?
5. What is your average workday like?
6. Do you work with a team?
   - How is your work divided?
7. Do you collaborate with other roles or teams?
8. What would you highlight as the key foundations that allow multiple people to work together on the same project?
9. What are the benefits of working with a team?
10. What are the disadvantages of working with a team?
11. Is there something that must be considered when working with a team?
12. What are the aspects that 3D environment artists must consider in their work while creating assets for video games?
13. Do you have experience with modular 3D workflow?
14. Where, how and why did you utilize modularity?
15. What would you define as the key concepts of modular approach to 3D modeling?
16. What must the 3D artist consider before / during using a modular workflow?
17. What are the benefits of using modularity?
18. What are the disadvantages of using modularity?
19. What techniques do you think compliment 3D modularity?
20. Have you experienced times when you decided between using or not using modular approach, why?
21. How does one mitigate the negative effects of modular workflow?
22. Do you think modular 3D methods will continue to be utilized by the industry?
23. Would you say that modular workflow benefits a multi-person pipeline?
24. Do you see any potential changes to the way that the modular workflow is used?
25. Any other thoughts or takes on the subject?
26. Any advice you wish you'd known when you first got started as a 3D environment artist?

Appendix 2

Caption of playground project GDD by Toivonen

Description

The playground is a small tech demo featuring an unnamed young boy with a mask as the main character in this empty but lush game world. The world appears to be in ruins and overtaken by a bunch of vegetation and some creatures of nature. The boy carries a malevolent entity in his mask as a curse binding the two of them together for the duration of a lifetime. The shadow in the mask is angry and out of control while the boy is calm and collected but still having that child-like spirit left in him and the two of them have to learn to live with each other and co-operate to survive in this new world that has been created.

Core Gameplay Mechanics

For the first MVP the main core mechanics consist of a movement system featuring climbing and a fighting system with combo movements with different types of attacks.

The movement system will feature the basic set of movements with omnidirectional movement on the ground, sprinting, vaulting and sliding. The climbing system will have a lot of variety to add a variety of opportunities for the player to explore but the core of that mechanic lies in the player being able to grab different kinds of ledges to climb them. Different jump and drop heights with the addition of side-to-side movement while hanging will result in different animations and movements performed by the main character.

The fighting system will feature a basic set of moves including a melee move and some shadow attacks including a heavy and a light attack while utilizing the mask. These attacks can then be possibly combined to make different kinds of stronger moves to overwhelm the enemy. The fighting system will also feature a dodge move to support the defensive side of fighting as well.

Project Scope

The MVP of the project is an area in the game world with the desired art style that features a small climbing challenge to demo the climbing system component and also an open area with a simple target to demo the fighting system component. The player should be able to get an understanding of the intended mechanics and also be able to experience the aesthetics created together with the combination of 3D assets and VFX and shader work.

More features can be added in the future if the team has time and energy to keep working on the project after the initial tech demo. More features like enemies can be added to better support the fighting system component and the climbing system can be expanded further with more possibilities is so desired. The collection VFX and 3D assets can also be expanded to make the game world even more impressive and appealing to the player. Also more work can be done to implement different weathers or possibly different types of environmental shaders the player is able to interact with while exploring and demoing the other mechanics.

Gameplay Summary

Being a tech demo rather than a full game the gameplay of the project remains quite simple. The player can explore the game world with the basic movement system and reach trickier spots with the robust climbing system. The level design in the little demo area of the full game world also supports the climbing system with different kinds of climbing challenges for the player to experiment with. The player can also experiment with a variety of attack combinations while fighting with the shadow bound to the main character's mask. The level will feature a simple target that the player practice different attack combos on. The fighting system will also feature a dodge roll to allow the player to also play a more defensive strategy when needed.

Movement

The movement system in the playground is designed around the main character being a young child who is very durable and agile. The movement system features the standard omnidirectional movement while on the ground. The player is always able to move around freely as long as their movement is not obstructed. On top of this, while moving, the character can jump, sprint, slide from sprinting and vault over obstacles.

Jumping is free-form and is possible anywhere as long as the player is already grounded. Double jumps are impossible to execute and the player has to rely on the climbing system over jumping high up. Basic jumping can be easily combined with different climbing moves.

Sprinting is possible while either holding or toggling the assigned key / button for sprinting. There is no stamina so the player is able to run infinitely as long as their movement is not obstructed. Sprinting will also allow access to a slide. The slide is standardized and will not change depending on the steepness of the terrain. Sliding will allow the player to pass under obstacles that couldn't be otherwise reached while standing up.

The player is able to perform different types of vault moves based on the obstacles' dimensions.

Modular kit mesh details

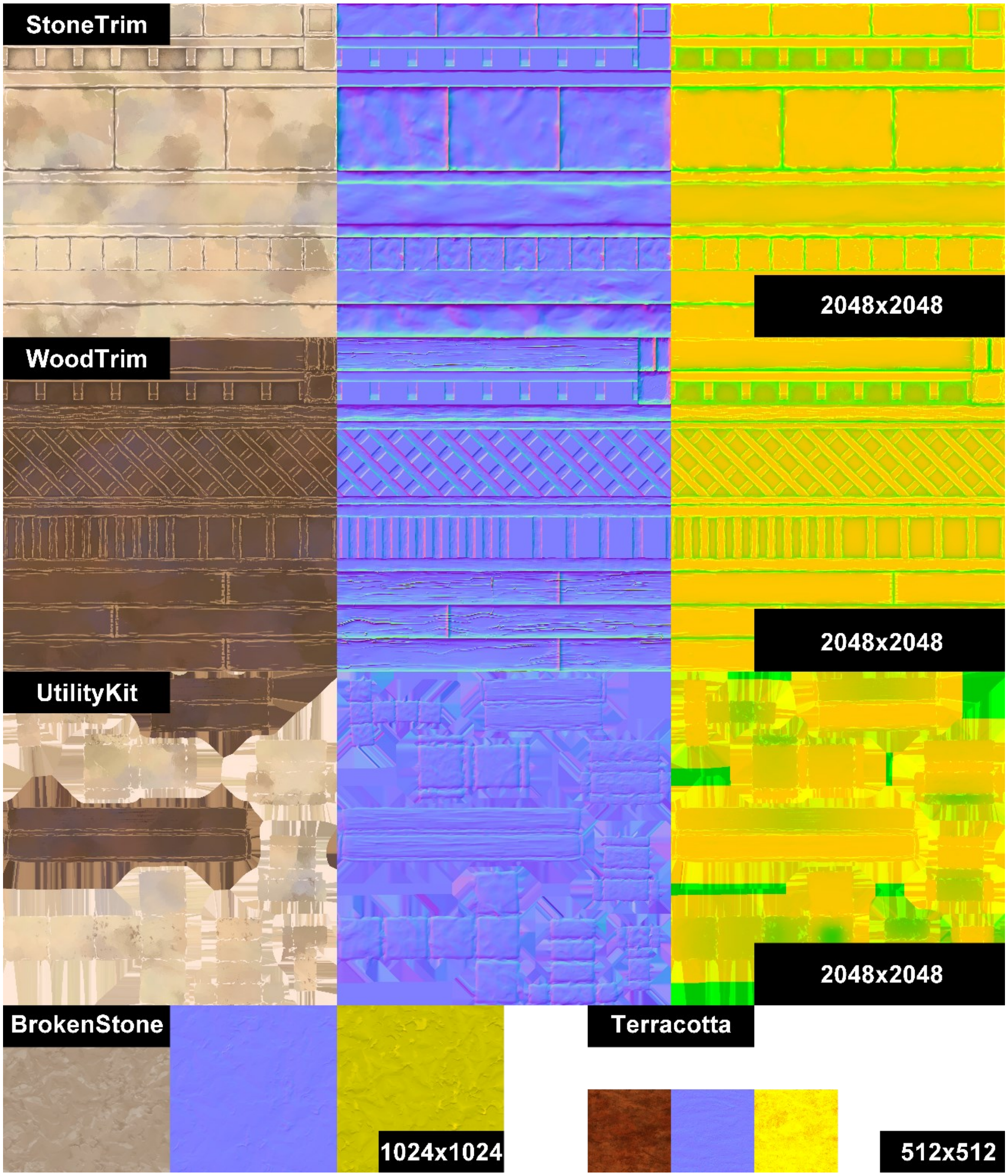
Asset Name	Asset Type	Kit Type	Size (m)	Polys	Vertices	Mat. Nu
Door_Large01	Door	UtilityKit	*	198	248	1
Door_Small01	Door	UtilityKit	*	142	176	1
Gate_Door_01	Door	UtilityKit	*	484	614	1
MK_Grdn_Wall_1m_01	Garden	GardenKit	1m	74	86	2
MK_Grdn_Wall_1m_CrnOut_01	GardenCorner	GardenKit	1m	112	124	2
MK_Grdn_Wall_1m_CrnT_01	GardenCorner	GardenKit	1m	168	185	2
MK_Grdn_Wall_1m_CrnU_01	GardenCorner	GardenKit	1m	162	167	2
MK_Grdn_Wall_1m_CrnX_01	GardenCorner	GardenKit	1m	224	246	2
MK_Grdn_Wall_2m_01	Garden	GardenKit	2m	148	162	2
MK_Grdn_Wall_2m_02	Garden	GardenKit	2m	108	113	2
MK_Grdn_Wall_2m_03	Garden	GardenKit	2m	96	101	2
MK_Grdn_Wall_2m_CrnIn_01	GardenCorner	GardenKit	2m	104	118	2
MK_Grdn_Wall_2m_DoorS_01	GardenDoor	GardenKit	2m	168	202	2
MK_Grdn_Wall_4m_01	Garden	GardenKit	4m	110	126	2
MK_Grdn_Wall_4m_02	Garden	GardenKit	4m	172	184	2
MK_Grdn_Wall_4m_CrnIn_01	GardenCorner	GardenKit	4m	176	190	2
MK_Grdn_Wall_4m_DblDoorS_01	GardenDoor	GardenKit	4m	418	561	2
MK_Grdn_Wall_4m_DoorS_01	GardenDoor	GardenKit	4m	168	202	2
MK_Grdn_Wall_Pillar_01	Garden	GardenKit	1m	181	185	2
MK_MNS_Floor_1x1m_01	Floor	FloorsKit	1m	6	8	1
MK_MNS_Floor_2x1m_01	Floor	FloorsKit	2m	10	12	1
MK_MNS_Floor_2x2m_01	Floor	FloorsKit	2m	16	18	1
MK_MNS_Floor_2x2mCube_01	Floor	FloorsKit	2m	24	26	1
MK_MNS_Floor_2x4mCube_01	Floor	FloorsKit	4m	40	42	1
MK_MNS_Floor_3x3m_01	Floor	FloorsKit	3m	30	32	1
MK_MNS_Floor_4x2m_01	Floor	FloorsKit	4m	28	30	1
MK_MNS_Floor_4x3m_01	Floor	FloorsKit	4m	38	40	1
MK_MNS_Floor_4x4m_01	Floor	FloorsKit	4m	48	50	1
MK_MNS_Floor_4x4m_Crn_01	Floor	FloorsKit	4m	46	48	1
MK_MNS_Overhang_1m_CrnOut_0	RoofOverhang	RoofKit	1m	180	271	2
MK_MNS_Overhang_2m_01	RoofOverhang	RoofKit	2m	106	176	2
MK_MNS_Overhang_4m_01	RoofOverhang	RoofKit	4m	202	336	2
MK_MNS_Overhang_4m_CrnOut_0	RoofOverhang	RoofKit	4m	554	896	2
MK_MNS_Pillar_2m_Crl_01	Pillar	PillarsKit	2m	360	362	1
MK_MNS_Pillar_2m_Sqr_01	Pillar	PillarsKit	2m	94	104	1
MK_MNS_Pillar_4m_Crl_01	Pillar	PillarsKit	4m	552	554	1
MK_MNS_Pillar_4m_Sqr_01	Pillar	PillarsKit	4m	158	168	1
MK_MNS_Pillar_Beam_2m	Pillar	PillarsKit	2m	34	36	1
MK_MNS_Pillar_Beam_4m	Pillar	PillarsKit	4m	58	60	1
MK_MNS_PillarArch_01	PillarCap	PillarsKit	*	426	456	1
MK_MNS_PillarCaps_01	PillarCap	PillarsKit	*	45	50	1
MK_MNS_PillarCaps_02	PillarCap	PillarsKit	*	214	230	1
MK_MNS_Roof_2m_01	Roof	RoofKit	2m	441	636	2
MK_MNS_Roof_4m_01	Roof	RoofKit	4m	861	1256	2
MK_MNS_Roof_4m_CrnIn_01	Roof	RoofKit	4m	1318	1935	2
MK_MNS_Roof_4m_CrnOut_01	Roof	RoofKit	4m	1283	1923	2
MK_MNS_Roof_Fence_1m_01	Fence	RoofKit	1m	168	170	3
MK_MNS_Roof_Fence_2m_01	Fence	RoofKit	2m	168	170	3
MK_MNS_Roof_Fence_2m_CrnIn_0	FenceCorner	RoofKit	2m	328	328	3

MK_MNS_Roof_Fence_4m_01	Fence	RoofKit	4m	232	234	3
MK_MNS_Roof_Fence_4m_CrnIn_0	FenceCorner	RoofKit	4m	456	456	3
MK_MNS_Roof_Fence_CrnOut_01	FenceCorner	RoofKit	1m	124	116	3
MK_MNS_Roof_Fence_CrnT_01	FenceCorner	RoofKit	1m	96	94	3
MK_MNS_Roof_Fence_CrnU_01	FenceCorner	RoofKit	1m	152	138	3
MK_MNS_Roof_Fence_CrnX_01	FenceCorner	RoofKit	1m	88	82	3
MK_MNS_Stairs_1x2m_01	Stairs	FloorsKit	2m	68	69	1
MK_MNS_Stairs_1x2m_02	Stairs	FloorsKit	2m	9	10	1
MK_MNS_Stairs_2x2m_01	Stairs	FloorsKit	2m	114	115	1
MK_MNS_Stairs_2x2m_02	Stairs	FloorsKit	2m	14	15	1
MK_MNS_Stairs_2x4m_01	Stairs	FloorsKit	4m	232	232	1
MK_MNS_Stairs_2x4m_02	Stairs	FloorsKit	4m	32	33	1
MK_MNS_Strip_1m_01	Strip	RoofKit	1m	46	48	2
MK_MNS_Strip_2m_01	Strip	RoofKit	2m	46	48	2
MK_MNS_Strip_4m_01	Strip	RoofKit	4m	66	68	2
MK_MNS_Strip_Arch_4m_01	Strip	RoofKit	4m	488	490	2
MK_MNS_Wall_2m_02	Wall	WallsKit	2m	196	190	3
MK_MNS_Wall_2m_03	Wall	WallsKit	2m	193	189	3
MK_MNS_Wall_2m_CrnIn_01	Corner	WallsKit	2m	368	362	3
MK_MNS_Wall_2m_CrnIn_02	Corner	WallsKit	2m	262	274	3
MK_MNS_Wall_2m_CrnIn_03	Corner	WallsKit	2m	250	242	3
MK_MNS_Wall_2m_DoorL_01	Doorway	WallsKit	2m	231	296	3
MK_MNS_Wall_2m_DoorS_01	Doorway	WallsKit	2m	223	286	3
MK_MNS_Wall_2m_Wdw_01	Window	WallsKit	2m	439	516	3
MK_MNS_Wall_2m_Wdw_02	WallWindow	WallsKit	2m	455	532	3
MK_MNS_Wall_2m_Wdw_03	Window	WallsKit	2m	393	459	3
MK_MNS_Wall_2m_Wdw_04	Window	WallsKit	2m	507	583	3
MK_MNS_Wall_2mShort_01	WallShort	WallsKit	2m	232	231	3
MK_MNS_Wall_2mShort_02	WallShort	WallsKit	2m	158	156	3
MK_MNS_Wall_2mShort_03	WallShort	WallsKit	2m	144	143	3
MK_MNS_Wall_2mShort_CrnIn_01	CornerShort	WallsKit	2m	360	347	3
MK_MNS_Wall_4m_01	Wall	WallsKit	4m	356	358	3
MK_MNS_Wall_4m_02	Wall	WallsKit	4m	365	353	3
MK_MNS_Wall_4m_CrnIn_01	Corner	WallsKit	4m	592	590	3
MK_MNS_Wall_4m_CrnIn_02	Corner	WallsKit	4m	489	474	3
MK_MNS_Wall_4m_CrnIn_03	Corner	WallsKit	4m	604	641	3
MK_MNS_Wall_4m_CrnIn_04	Corner	WallsKit	4m	604	641	3
MK_MNS_Wall_4m_CrnIn_05	Corner	WallsKit	4m	934	1082	3
MK_MNS_Wall_4m_CrnIn_06	Corner	WallsKit	4m	763	836	3
MK_MNS_Wall_4m_CrnIn_07	Corner	WallsKit	4m	763	836	3
MK_MNS_Wall_4m_CrnIn_08	Corner	WallsKit	4m	582	646	3
MK_MNS_Wall_4m_CrnOut_01	Corner	WallsKit	1m	204	202	3
MK_MNS_Wall_4m_CrnT_01	Corner	WallsKit	1m	230	224	3
MK_MNS_Wall_4m_CrnU_01	Corner	WallsKit	1m	216	216	3
MK_MNS_Wall_4m_CrnX_01	Corner	WallsKit	1m	256	242	3
MK_MNS_Wall_4m_DblDoorL_01	DoorWay	WallsKit	4m	413	461	3
MK_MNS_Wall_4m_DblDoorS_01	Doorway	WallsKit	4m	3551	391	3
MK_MNS_Wall_4m_DoorL_01	DoorWay	WallsKit	4m	425	493	3
MK_MNS_Wall_4m_DoorS_01	DoorWay	WallsKit	4m	357	419	3
MK_MNS_Wall_4m_Gate_01	Doorway	WallsKit	4m	543	645	3

MK_MNS_Wall_4m_Wdw_01	Window	WallsKit	4m	529	608	3
MK_MNS_Wall_4m_Wdw_02	Window	WallsKit	4m	549	628	3
MK_MNS_Wall_4m_Wdw_03	Window	WallsKit	4m	554	648	3
MK_MNS_Wall_4m_Wdw_04	Window	WallsKit	4m	678	839	3
MK_MNS_Wall_4m_Wdw_05	Window	WallsKit	4m	668	820	3
MK_MNS_Wall_4m_Wdw_06	Window	WallsKit	4m	724	866	3
MK_MNS_Wall_4mShort_01	WallShort	WallsKit	4m	294	293	3
MK_MNS_Wall_4mShort_02	WallShort	WallsKit	4m	292	287	3
MK_MNS_Wall_4mShort_CrnIn_01	CornerShort	WallsKit	4m	480	476	3
MK_MNS_Wall_4mShort_CrnOut_0	CornerShort	WallsKit	1m	172	161	3
MK_MNS_Wall_4mShort_CrnT_01	CornerShort	WallsKit	1m	200	182	3
MK_MNS_Wall_4mShort_CrnU_01	CornerShort	WallsKit	1m	184	176	3
MK_MNS_Wall_4mShort_CrnX_01	CornerShort	WallsKit	1m	232	194	3
MK_MNSIn_Wall_1m_01	WallInteriorCorne	WallsKit	1m	166	168	3
MK_MNSIn_Wall_2m_01	WallInterior	WallsKit	2m	242	244	3
MK_MNSIn_Wall_3m_01	WallInterior	WallsKit	3m	204	206	3
MK_MNSIn_Wall_3m_02	WallInteriorDoor	WallsKit	3m	229	265	3
MNS_Strip_1m_CrnOut_01	StripCorner	RoofKit	1m	80	76	2
MNS_Strip_1m_CrnT_01	StripCorner	RoofKit	1m	96	92	2
MNS_Strip_1m_CrnU_01	StripCorner	RoofKit	1m	96	92	2
MNS_Strip_1m_CrnX_01	StripCorner	RoofKit	1m	136	122	2
MNS_Strip_2m_CrnIn_01	StripCorner	RoofKit	2m	110	108	2
MNS_Strip_4m_CrnIn_01	StripCorner	RoofKit	4m	152	150	2
Utl_Stone_Brick_01	Brick	UtilityKit	*	234	236	1
Utl_Stone_Brick_02	Brick	UtilityKit	*	160	162	1
Utl_Stone_Brick_03	Brick	UtilityKit	*	150	152	1
Utl_Stone_Brick_04	Brick	UtilityKit	*	238	240	1
Utl_Stone_Brick_05	Brick	UtilityKit	*	174	176	1
Utl_Stone_Brick_06	Brick	UtilityKit	*	150	150	1
Utl_Stone_Brick_07	Brick	UtilityKit	*	110	112	1
Utl_Wood_Plank1m_01	Plank	UtilityKit	1m	376	378	1
Utl_Wood_Plank2m_01	Plank	UtilityKit	2m	594	596	1
Utl_Wood_Plank3m_01	Plank	UtilityKit	3m	594	596	1
Utl_WoodBeam_2m	Beam	UtilityKit	2m	38	40	1
Utl_WoodBeam_4m	Beam	UtilityKit	4m	70	72	1

Appendix 4

Final modular kit textures



Appendix 5

Applications of the modular kit