

How Game Development Technology Can Assist in Visualisation Challenges:

A Study

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HOW GAME DEVELOPMENT TECHNOLOGY CAN ASSIST IN VISUALISATION
CHALLENGES.

By

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Abstract

Research has shown that product configuration is becoming an increasingly common aspect of commercial sales, where previously it would have been an advantage that sets your products apart from competitors, it's now becoming normalised as a baseline service offered to customers. Product configurators are notoriously difficult to develop, often requiring mass amounts of content and data. Larger businesses with resources to spare can afford to take on the risks associated with developing a product configurator, but medium and smaller sized businesses often cannot, and so find themselves at an increasingly larger disadvantage.

This study aims to investigate whether game technology can mitigate or remove some of the development risks associated with developing a product configurator.

Building on existing work on product configurator development, it asks. Can game technology provide an advantage over traditional development solutions? And if so, how exactly does it improve on them

Based on a review of the literature on product configurator development, it's clear that traditional rendering solutions are fine if the products showcased feature low-levels of customisation. But if products exceed this customisation threshold, it's evident that these practices cannot scale and so bottleneck production, making the investment and risk involved in continuing development too high.

The results indicate that when using game technology, you can automate aspects of production, such as rendering and storage. The speed difference between traditional rendering solutions and game technology methods are considerable if implemented correctly.

On this basis, it is recommended that game technology is used in place of traditional rendering solutions such as Blender, 3DS Max and other 3D rendering packages as the difference in production speed is immense and the inclusion of automating certain tasks outright removes certain tasks involved in the production of a product configurator.

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1. INTRODUCTION

The computer games industry is one of the most competitive commercial industries in the world. Part of the reason for this is that the tools of production are more readily available than analogous counterparts featured in other industries. Not everyone can gain access to a CNC machine or a 3D printer, but if they so choose, anyone can gain access to most modern game engines for free. This newfound access, alongside the ever-increasing availability of the internet, is providing people with the ability to train themselves on how to utilise game technology like never before. This transition has led to an era of innovation in games technology that is seemingly only gaining momentum over time. For instance, Unreal Engine 4 is just one of many computer game engines available for free. Built primarily to be a game engine; its release was in September 2014. As of January 2020, it is active in the Architecture, Automotive, Film, Media, Entertainment, News, Medical, Military, Training and Simulation industries. Its inclusion in industries outside of its origin demonstrates that ample opportunity exists to exploit the advantages of game technology for use in other endeavours outside of creating computer games. One of these endeavours is product visualisation.

Product visualisation is the art of showing a customer the product that they want to see. It creates idealisms of products that would otherwise be visualised by a customer's imagination. However, a product is not just the sum of its aesthetic appeal; other values such as price, delivery and customisable features all play a role in persuasion. A product configurator is a perfect vessel to communicate these values to a customer, making it a potent tool. This potential has led to the development of many commercial product configurators, most – if not all, automate some aspect of the customer experience. Speaking about product personalisation in 2014 Siemens CEO Eric Spiegel said that manufacturing in the USA was in the middle of a "software revolution" and that in his opinion, it would lead to the "mass customisation" of products around the globe (Mageean, 2019). His projection has somewhat come to pass; in 2015 YouGov conducted a poll to find that just one in six American consumers had purchased a personalised product. In 2019 this increased to one in four American consumers (Made to Order, 2020).

However, there is a problem; not everyone can afford the financial cost or risk associated with developing a product configurator. Ironically the type of businesses that this becomes most apparent to are the very businesses that would benefit the most. One of the biggest weaknesses of product configurator projects (Haug, Hvam and Mortensen, 2012) is the sheer amount of content that needs creating. Because of this, many projects do not reach a point where they offer any return on investment. For many small and medium businesses, this potential outcome presents a risk too large to take on in good conscience.

This weakness is where the focus of this research will centre around, an exploration of how game technology could potentially mitigate or automate aspects of a product configurators production so that it minimises the risk of the project not reaching fruition. These themes will be investigated and tested with a case study - the development of a product configurator for a company called REM. REM is a furniture manufacturing business based in the UK who specialise in various customisable products. However, this customisation is coming with a cost. Increasingly REM is finding that their customers either do not want or lack the ability to accurately imagine what a product will look like in different colours or variations. Feedback from the customer base indicates that the consensus on product customisation is overwhelmingly positive. In-fact feedback from their customers and wholesalers

indicates that the general opinion held by people when asked is "the more customisation, the better". Nevertheless, once presented with products that reflect this feedback, wholesalers struggle to sell the product due to the various customisation rules that the purchase must follow. Due to wholesalers struggling, customers do not feel enthused about new products due to the overwhelming amount of choices and considerations that they have to make with limited support.

With this in mind, REM decided that they were going to address this problem using a product configurator. However, REM as a company does not feature an IT department or any trained staff that could even conceptually start work on a complex product configurator. This realisation was when REM reached out to Manchester Metropolitan University for help in the guise of a KTP project. The KTP project was a 30-month endeavour where the aim was to not only create a product configurator for REM's products but to attempt to ensure that whatever form the solution took, that it was as hands-off as possible and could be used by an existing member of staff with minimal training. The pathway on how this was to be achieved was left completely undefined, the only request by REM was that the product configurator needed to be available for public use by July 2019 at the latest. The KTP project started development in January 2017; this is where the case study regarding development begins.

The objective is to develop a product configurator for REM using game technology instead of traditional rendering solutions. This research will focus specifically on a critical question and its subsequent implications:

- Can game technology successfully be applied to the development cycle of a product configurator?
- Does applying said technology improve the productivity or performance of the development cycle?
- What are the specific aspects of the development cycle that game technology can help?

The key participants in the KTP project are Niall Arnfield (Principle Investigator), Anthony Bukowski (Academic Supervisor), the design department manager of REM, Paul Peak, and the finance director of REM, Chris Blakey. The research included in this dissertation took place at REM between January 2017 and July 2019.

The work in this dissertation is structured as follows: Chapter 2 reviews relevant concepts and literature on what a product configurator and the tasks involved in creating one. Additionally, it explores the fundamental components of technologies involved in creating a product configurator. Chapter 3 outlines the hypothesis. Chapter 4 establishes the aims of the research. Chapter 5 explores the process of developing the product configurator for REM, featuring specific examinations of how and why each element of development was conducted in the way it was. Chapter 6 features the results of the solution developed in Chapter 5. Chapter 7 explores possible improvements to the developed solution and outlines research opportunities for the future.

2. LITERATURE REVIEW

2.1. REM PROJECT OVERVIEW

Before this research started, REM had already obtained a development overview for creating a product configurator. It was drafted for REM by a local professional 3D rendering and web development company in 2016. The project overview proposed that;

- Autodesk 3DS Max would render images of products.
- Product images would be stored in a database, from which the solution would return images.
- The solution would be programmed using HTML5, CSS3, JavaScript, PHP and XCode for iOS.
- Product models would be imported from existing CAD (Computer-aided design) drawings, and these drawings would not be changed in any way.
- Images would need to be named, sorted and administered over time (a naming convention or labelling structure was not defined in the development breakdown).
- Once developed, the solution would release on the iOS store in 2018.

The timeline quoted for this project was 20 months, with the admission that most of this time would be spent rendering product images in Autodesk 3DS Max. It was intended that an image would be rendered for every single product colour combination, but that some products had too many combinations to be realistically included, these products were excluded from development. The total amount of images required using this production methodology would be 282,320. This figure does not include the products that were too complex to add to the product configurator. The estimated time given for how long it would take to complete the product renders was 360 days. The estimated staff requirement was three staff members. Two staff members would be working on product renders, the third would be working on developing the iOS application and its backend requirements. A visualisation and table demonstrating the proposed timeline for developing the product configurator are featured below.

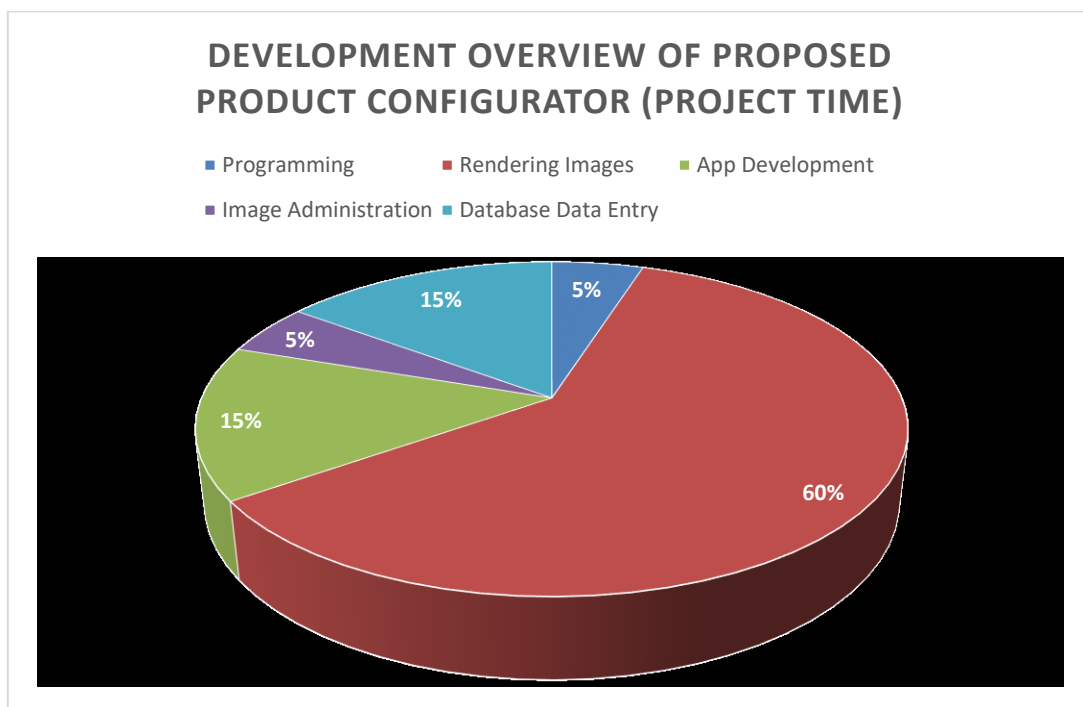


FIGURE 1 – ESTIMATED DEVELOPMENT TIMELINE OF THE PROPOSED PRODUCT CONFIGURATOR

Task Name	Estimated Time (Days)
Programming	30
Rendering Images	360
App Development	90
Image Administration	30
Database Data Entry	90

TABLE 1 - ESTIMATED DEVELOPMENT TIMELINE OF PROPOSED PRODUCT CONFIGURATOR

As detailed above, 60% of the 20-month development timeline was to be spent on rendering images of products in different colour combinations. 5% of the time was to be spent sorting and storing these product images so that they could be uploaded to the database in a structured manner. Programming the database and applications backend structure would take another 5%. 15% of the project was to be used to upload all the product images to the database manually. Finally, another 15% of the total project time was to be spent on designing and developing the iOS application, which would, providing that everything went well, be tentatively released in 2018.

REM eventually decided that this project proposal was not viable for several different reasons. Firstly, the developers insisted that once the 20-month project development time ended, the project would transition into a 6-month annual update cycle. REM updates its products every year with both physical and colour combination changes. The final decision for these changes is made at the end of October in any given year, so, there exists only a two-month update window for the product configurator update cycle to happen within, which was far less than the 6-month window the developers wanted. Secondly, the requirement of three staff members was too much change in REM's employment structure for a singular project. As mentioned in Chapter 1, one of the biggest dangers of a product configurator project is that it never reaches a point in development in which it can be utilised to produce revenue, so the proposal that REM hired three new workers to only give the project a prospective chance at this return on investment was deemed as too great of a risk to the business. Finally, the focus on developing the application singularly for iOS led to a debate on whether the application could eventually be deployed to other platforms (Web, Android, PC), the developers admitted in this instance that they were unable at that point to correctly advise on whether it would be possible to do so. This was a decisive negative attribute for the project proposal as one of REM's biggest incentives in undertaking the project was that eventually, it could hand the product configurator over to its wholesale partners, with the long-term plan being that they could utilise it in stores across the country. Having the application limited to iOS meant that there was a genuine chance that a sizeable proportion of these wholesalers would not be able to utilise it at all. Based on this REM specified some objectives that needed to be completed for any project proposal to be deemed viable, these were;

- Updating the product configurator with annual changes could take no longer than two-months.
- Once developed, it must be available for its wholesalers to use across the country.
- It must feature every product in every single combination.
- It cannot require three staff members; ideally, it would be developed by one person.
- It must be available to use on PC, tablet and mobile.
- It must be ready for release by July 2019.

2.2. PRODUCT CONFIGURATORS

A product configurator is a tool that makes it possible for customers to design or personalise the products they intend to purchase. They are a visualisation tool which helps showcase all possible variations available for a given product (Trimit, 2018). For many manufacturing companies, the era of standardising products with a limited set of options has ended. Due to technological progress, customer demand and the rising importance to have products or brands stand out, many manufacturing companies have turned to the development of customisable products. In previous times the cost of being able to customise a product was very high, high enough that it often created products that were too expensive for customers to consider buying, or too expensive for a manufacturer to consider producing. The idea of product configuration was a sound one, but its real-world implementation and consequences made it problematic. However, now that a new generation of consumers has entered the market, attitudes have changed, 1 in 10 American consumers now considers product personalisation a top interest when buying a product and 40% of people who purchase personalised products are from the millennial generation (Made to Order, 2020).

Interestingly product configuration is now also being used in a defensive manner to combat against product design plagiarism. Countries with low-cost manufacturing production have perennially attempted to copy successful product designs from other companies, in the hopes of replicating customer interest in cheaper versions. Introducing a product configurator that personalises a product to a user's specification facilitates the customer considering the product to be of their design, so while some companies may well be able to reproduce the product at lower prices, they are unlikely to be able to recreate "your" personalised product. Other advantages of implementing a product configurator include reducing lead times, reducing staff encumbrance with enquiries and complaints, automating price delivery and quotation systems, increasing brand perception, reducing ordering mistakes and potentially increasing sales.

The cascade effect that this has created in many different industries is evident, once one business has a product configurator, customers within that consumer base consider it an expected element of the sales process. So once one business successfully deploys one of these solutions, competitors often respond with their own. The more this happens, the more pressure is applied to the remaining businesses who have not yet released their own. Lost potential revenue means that in some cases if a business waits too long to respond to a competitor's innovation, they can eventually find themselves unable to do so due to a lower revenue stream.

Many customers now expect to be able to pick the colours of a product, its options and find out its price, all without speaking to any sales agent or visiting a showroom. For many people, this is because as prospective customers, they care more about establishing what is inside their budget, rather than just browsing products irrespective of whether they eventually intend to buy.

But modern-day product configurators are not just limited to being customer only solutions, they have been found to yield impressive results when they are implemented into other sectors of a business, several different types of these configuration solutions are;

- Knowledge-based Configurators
- Manufacturing Resource Planning Configurators
- Product Visualisation Configurators

- Enterprise Product Configurators

Knowledge-Based Configurators (KBC)

KBC tools are targeted at increasing the productivity of engineers. KBC tools are often used when the product design is intricate. KBC tools integrate with computer-aided design software (CAD). They can reduce the number of menial tasks in technically drawing products so that the engineer in question can focus their time on the more complex or custom aspects of a product.

Manufacturing Resource Planning Configurators

Manufacturing Resource Planning (MRP) configurators aim to provide internal departments, typically customer service departments the ability to generate an order within a pre-defined set of product rules. Companies with many stores, local teams or customer sales departments would benefit the most by reducing the time and cost required to train staff on the specificity of the products that they are selling or processing. These solutions are often text-based as they exist only internally within a business and their goal is not to increase sales, but to decrease administration overhead and the chance that an order entry error occurs.

Product Visualisation Configurators

Product Visualisation Configurators (PVC) are typically used in customer-facing environments to increase sale conversion rates. These applications provide the user with a visual representation of the configured product, either in 2D or 3D. They are often featured online but can also be present in retail stores. Unlike other types of product configurator solutions, PVC applications come with the cost of having to create the products being sold in 3D, often to a photo-realistic standard. Which, depending on how many products there are, could prevent many businesses from being able to afford the development.

Enterprise Product Configurators

An Enterprise Product Configurator is a solution that uses aspects from the three previous types of configuration tools and attempts to apply them throughout a business. Instead of focusing on one singular aspect of production or administration, EPC solutions approach the application of such methods holistically, attempting to bring the benefits of a product configuration system to bear on as many different areas as possible. Its development happens incrementally, for example, development could begin with a KBC configuration system, but once this increment was deemed a success, development would begin on expanding its abilities and features into other sectors of the business, for instance, adding the ability for it to generate quotes automatically or for it to have the ability to show visualisations of products to the engineers. These types of product configurators have the highest potential to improve a business's outcomes, but they also come at a high cost.

Before development begins on the REM product visualizer configurator, it would be in good practice to investigate some relevant examples of product configurators that are available for the public to use. These examples may help provide a design archetype that once realised, could be used in part to design the REM solution or additionally, it could provide examples of what not to do regarding development choices and design principles. Below is a selection of pertinent examples of product configurators.

Tesla Design Studio

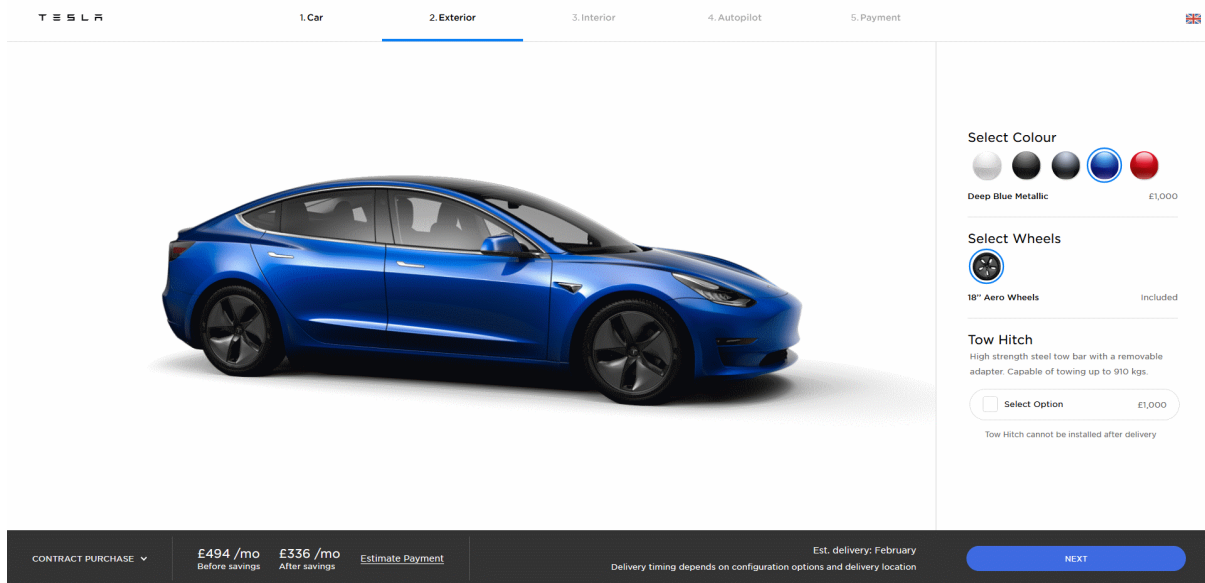


FIGURE 1 - THE TESLA DESIGN STUDIO CAR CONFIGURATOR

The Tesla car configurator is a web-based 2D product configurator that is hosted on the company's website. It is featured as part of their car ordering process to reduce ambiguity and inform customers of optional extras. It is delivered in tandem with typical data collection and validation structures that are expected from any commercial ordering system (Tesla.com, 2020).

Xbox Design Lab

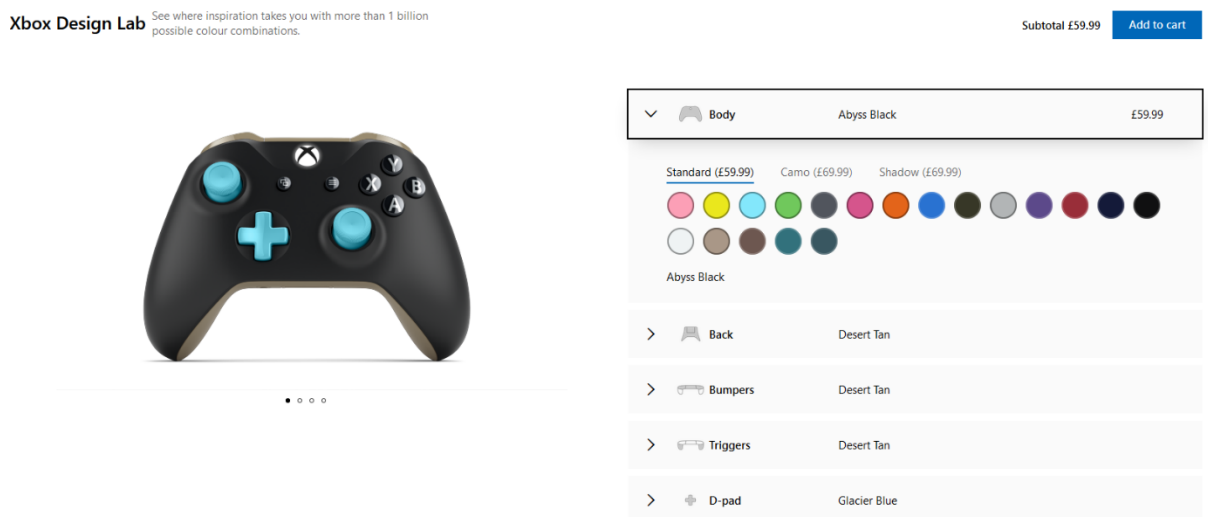


FIGURE 2 - THE XBOX DESIGN LAB CONTROLLER CONFIGURATOR

The Xbox Design Lab is a web-based 2D solution that is hosted on their company website. Its purpose is to allow customers to customise an Xbox One controller. The view of the controller can be changed, allowing users to see it from four different angles. These view changes reflect the current set of selections the user has already made (Microsoft.com, 2018).

It is not apparent how this visualiser loads its resources. The potential combinations of images would be in the billions, so a database of individual images would seem inappropriate. Nevertheless, there are no technical limitations to why this would not be possible. It is also possible that the visualisation is a composite of overlapping images. However, there are no indicators of this being true. A composite image solution would drastically reduce the number of images needed to create the visualisation. This method would typically create an observable overlap border where the composited images met. However, this outcome is not perceivable on the renders.

Porsche Car Configurator

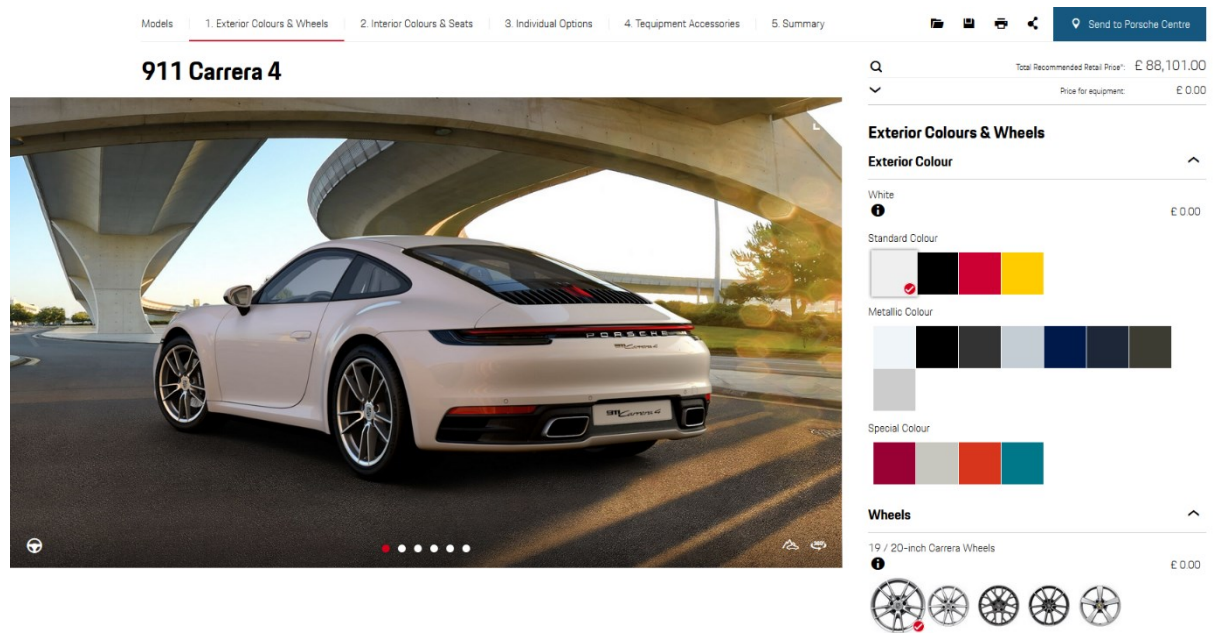


FIGURE 3 - THE PORSCHE CAR CONFIGURATOR

The Porsche Car Configurator is both a 2D and a 3D product configurator hosted on their company website. Its purpose is to create quotes that are sent to local Porsche car centres for sale lead generation. A user can take a screenshot of the product at any time. Unlike other product configurators, the background scene is highly customisable, scene environments can be changed, camera perspectives can be manipulated, animations can be activated, and users can select to view the product from either an interior or exterior perspective (Porsche.com, 2018).

It does everything that a product configurator should do from a design perspective; it captures data, provides feedback to the user in the form of cost estimate calculations, has an in-built solution for sending quotes to sales lead teams, and manages to do all this without compromising on the visual quality of presenting its products.

Indian Motorcycle Configurator

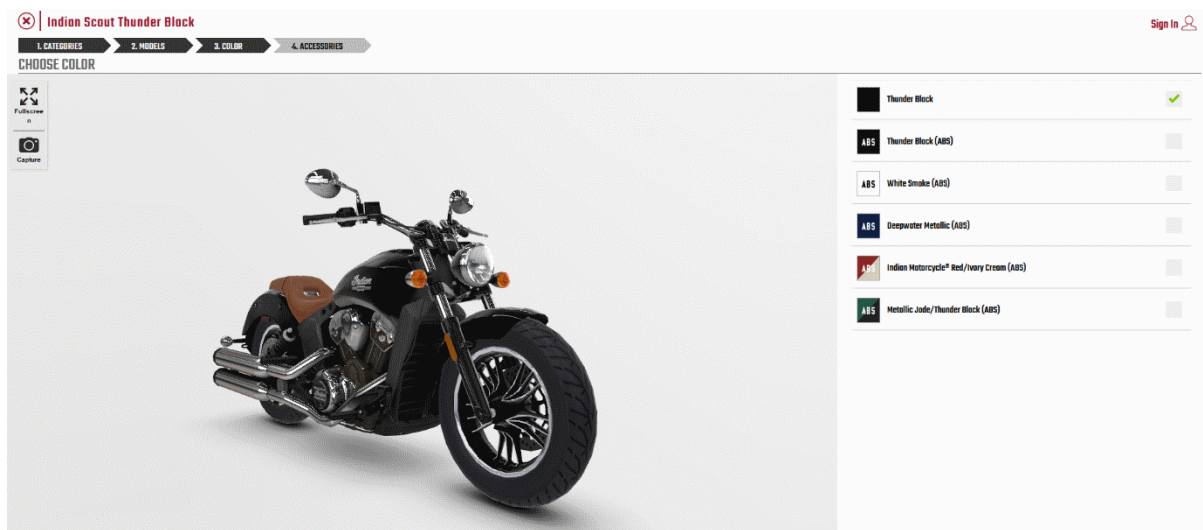


FIGURE 5 - THE INDIAN MOTORCYCLE PRODUCT CONFIGURATOR

The Indian Motorcycle product configurator is a web-based 3D solution. It is featured as part of their quote process to advertise different aspects of a motorcycle to the customer. The implementation uses a WebGL based game engine named PlayCanvas (PlayCanvas, 2020) to provide visualisation (IndianMotorcycle.com, 2018). The advantage of this solution is that it can be viewed in 3D across different platforms. The only disadvantage for this product configurator is that its core features are built using third-party solutions. So, its longevity is inextricably tied to the success or failure of that platform.

Motorcycle Helmet Configurator



FIGURE 4 - THE HELMADE MOTORCYCLE HELMET PRODUCT CONFIGURATOR

The Helmade motorcycle helmet product configurator allows users to customise elements of advertised products, namely the colours and finishes. This solution has been created using WebGL2 and is embedded seamlessly into the company's website. The 3D models can be rendered on both desktop and mobile. The solution also incorporates price generation and a direct-sale capability where the user's specification is directly added to the basket, ready for purchase (EN, 2020).

Based on the examples investigated, it is reasonable to establish some key points and observations related to the design, development and implementation of a product configurator, which can be used to help the development of the REM product configurator project. While several different design methodologies are available, for this project, it is apparent that REM will only require a product visualisation configurator. There are several reasons for this; primarily the configurator is intended to be used in customer-facing environments, for instance, wholesaler stores, showrooms and external sales staff conducting consultations. The only reasonable way for it to achieve all these aims is for it to be available online; this way, all potential users are having the same experience and are having the same information presented to them. Updates will be consolidated to just one platform, and deployment will be streamlined.

The industry examples covered previously provide a guide as to what design elements this solution should feature. Each example features elements that are consistent through most, if not all product visualisation configurators, for this project, these elements are defined as:

- Product Orientation
- Product Visualisation
- View Manipulation
- Geometry Manipulation
- Colour / Material Manipulation
- Content and Storage

Product Orientation

Product Orientation is the baseline communication of what the product is, how the product is currently customised, and what features are available for customisation. The user should not need to know anything about the product before them using the configurator. If they do not, they should not be at any real disadvantage to those who do.

Product Visualisation

This is the ability to visually demonstrate a user the current status of the product that they are customising, and it should update when a user makes a new selection.

View Manipulation

View manipulation is the ability to see the product from a different perspective or angle; it also could include the ability to view the internal or parts of a product if needed.

Geometry Manipulation

Geometry manipulation is the ability to change physical elements on a product, for instance, adding or subtracting optional components. 3D rendering on websites must use minimal resources. So geometry manipulation may only be a good idea when the assets being used are optimised for rendering performance. Primarily its principle is the same as Colour / Material Manipulation. However, its technical execution is different, and therefore, not all product configurators may be able to accommodate this requirement.

Colour / Material Manipulation

Colour Manipulation is the ability to change the colour on a given surface or mesh. These are often RGB colours, but an effort should be made to ensure that the colours represented on screen mimic with reasonable accuracy those that are applied in the manufacturing process.

Content and Storage

This is the ability to export or push data out of the product configurator once the user has finished their customisation. The guiding principle is that at a bare minimum the customer should be able to leave the product configurator with a reference code which they can give back to the manufacturing company that communicates the specific product that they created using the product configurator.

Now that it has been identified that the REM configurator will be a web-based product visualizer, the next decision to make is what kind of visualisation method it will feature? On review it seems that there are three available development pathways to take, they are;

- Write a custom 3D application using an open-source API (i.e. WebGL, OpenGL).
- Use a third-part 3D solution like PlayCanvas or PlayCanvas.
- Create a library of 2D images and deploy them on a traditional website (HTML5, CCS3).

Custom 3D Application

Writing a custom 3D application would likely produce the best overall solution for the product visualiser over time. However, the time and work it would take to get it to that point would be more abundant than the alternatives.

Third-Party Solution

Using a third-party solution, for instance, PlayCanvas would provide good results in a reasonable amount of time, but the application's functionality would depend on the functionality provided in the PlayCanvas or other platforms API development. This would always bottleneck future development and updates.

Traditional Website using 2D Images

Creating a library of 2D images and implementing them into a traditional web platform has the benefit of removing any application integration or API issues since it is just a regular webpage. The problems would occur when developing the product image library and figuring out how to render all these images in a reasonable amount of time.

2.3. GAME TECHNOLOGY

Game technology is a sub-field of game development that focuses on utilising the tools involved in game development for purposes outside of developing games. This field is very diverse and often fosters unlikely collaborative projects with partners far removed from the games industry. Games technology often focuses on facilitating the technical development of a project rather than the creative outcomes themselves, this emphasis leads to both hardware and software innovations and developments being created, as one begets the other. From a game technology perspective, its purpose is not to be the artist, but to provide the artist with the best tools available so that their outcomes, whatever they may be, can be as successful as possible.

Examples of game technologies successes are often overlooked. As stated previously game technology only facilitates the development of a project's goals. So, its inclusion is usually mentioned as a contributory factor rather than an accomplishment in and of itself, but that is not to say that success stories are being missed, below is a sample of several successful game technology projects in the recent past.

American Museum of Natural History (AMNH) Augmented Reality Experience



FIGURE 7 - FLY LIKE A PTEROSAUR AT THE AMERICAN MUSEUM OF NATURAL HISTORY

Featured as a limited-time exhibition piece, a motion-based interactive game called "Fly like a Pterosaur" was opened to the public as part of the exhibit "Pterosaurs: Flight in the Age of Dinosaurs". The exhibit ran from April 5th, 2014 to January 5th, 2015. This application allowed users to simulate the environments that Pterosaurs traversed. Its motion tracking was captured by a Kinect sensor (Vice, 2020).

Kinect sensors were a hardware addition released for the Xbox 360 games console on February 1st, 2012, but as demonstrated with this example, found application in many projects that required the capture of a user's motion (En.wikipedia.org, 2020).

Barry Joseph, the associate director of digital learning at AMNH said that the justification for using games technology in the museum was that; "We wanted to offer something to people that makes them want to leave their home, come to the museum, and experience something, and it also gives them an opportunity to not only appreciate but connect with the objects themselves." (Vice, 2020).

Booz Allen Hamilton Paratrooper Training

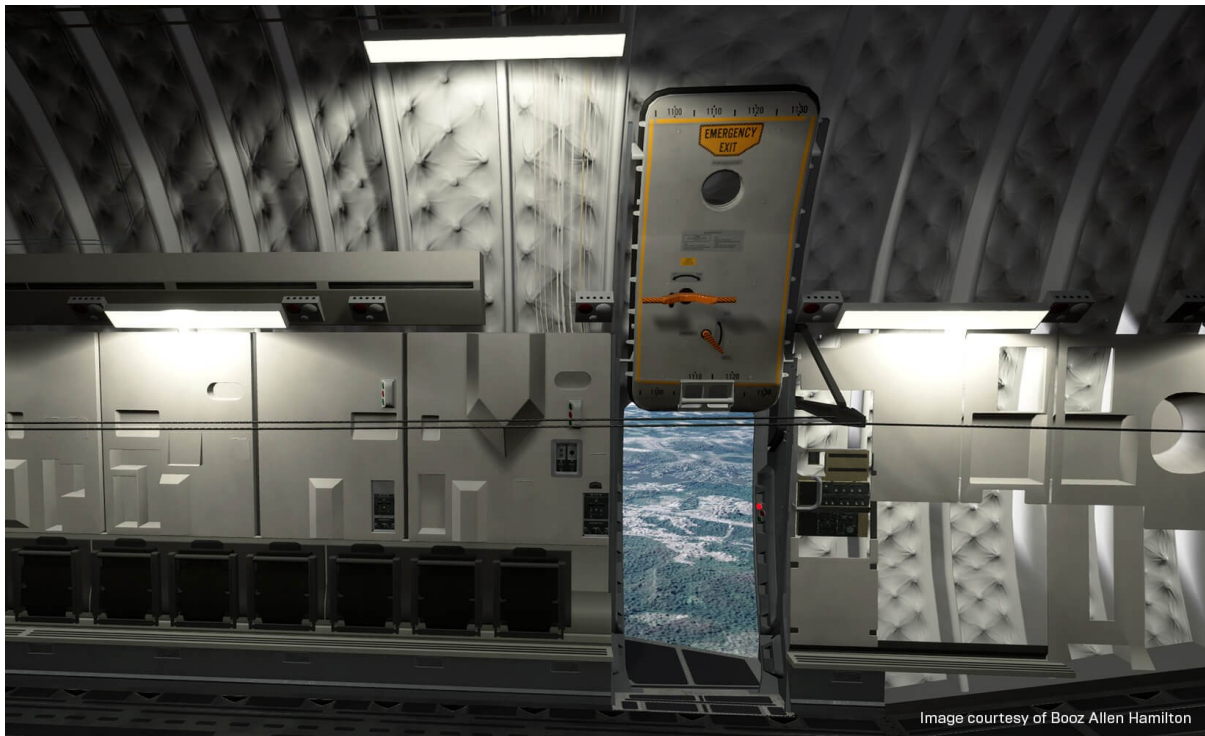


FIGURE 5 - THE BOOZ ALLEN HAMILTON PARATROOPER VR TRAINING SIMULATOR

Booz Allen Hamilton is a management consulting company that provide custom training solutions to the defence industries. In recent projects, the company has started to use Unreal Engine 4 to create these experiences. One of the first projects released with this development pipeline was virtual reality training on the safety considerations for new Jumpmasters. Jumpmasters are expert paratroopers in the US airborne unit. With the advent of this VR solution, Booz Allen Hamilton now teaches them how to safely jump from planes and to manage jump operations before the need for any real-world field training (Unreal Engine, 2020).

Derald Wise, a virtual reality developer at Booz Allen Hamilton, said that while a key part of the training is still done in the real world, safety constraints and budgets limit the extent to which live training can prepare a Jumpmaster for a real mission. Virtual training shines in that it does not have these constraints, making training repeated and effective (Unreal Engine, 2020).

Ikea Furniture Lab Augmented Reality Showroom



FIGURE 6 - IKEAS PLACE AR APPLICATION

Released in September 2017, IKEA's augmented reality iOS application called "Place", allowed anyone to drop virtual furniture into their own homes and view it through their smartphone camera. This application was one of the first to utilise ARKit; Apples augmented reality framework API that lets developers use a smartphones motion sensors and cameras to overlay digital objects on top of the real-world environment (Reynolds, 2020).

Orthopaedic Surgical Training in Virtual Reality

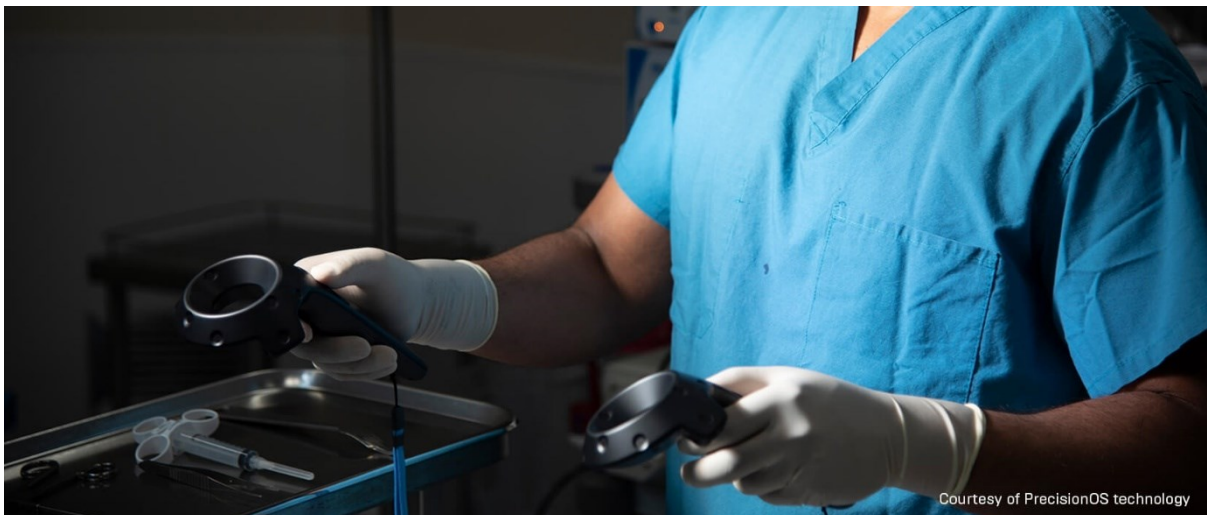


FIGURE 7 - PRECISION OS'S VR ORTHOPEDIC SURGERY SIMULATOR

Traditionally, surgeons have trained using plastic models and cadavers. However, these materials do not simulate the actual conditions of surgery accurately enough. To help with this Precision OS has developed a VR solution that trains orthopaedic surgeons by more accurately simulating the surgical environment. The goal is to simulate the real environment as closely as possible, enabling students to

experience what surgery looks and feels like (Unreal Engine, 2020). The solution utilises Unreal Engine 4 and the HTC Vive VR controller.

The orthopaedic surgeon who devised the idea to create this solution was Dr Danny Goel, in an interview with Epic he said that unlike other VR solutions, this solution has an extra ethical issue relating to the accuracy of the simulation, and that; "Misrepresentations and over-optimism of VR are critical elements when creating something with consequences to actual patients. We are sensitive to both and are researching all aspects of virtual reality. A second and important element to also consider is the point about empathy. It is important for the trainees to remember how their practice has implications to patient lives." (Unreal Engine, 2020).

Walt Disney Animation Studios Cycles Virtual Reality Story Telling



FIGURE 8 - WALT DISNEY ANIMATION STUDIO'S VR SHORT-FILM CYCLES

Premiered in 2018 "Cycles" is an immersive VR short film created by Walt Disney Animation Studios that use the Unity game engine. Its total production cycle was only 4-months, so to speed up development, many of the assets used in the simulation were sourced from other rendering projects. Unfortunately, these assets were not intended to be rendered in real-time, so much work had to be done to clean up the complexity of these assets and reduce their polygon count before they could be implemented into Unity and rendered at a frame-rate conducive with a professional VR experience. The inclusion of VR was not the only game technology used in this project; the film featured an augmented reality poster which was also created using Unity (Technologies, 2020).

BMW Mixed Reality Automotive Design



FIGURE 9 - THE BMW MIXED REALITY DESIGN SUITE

BMW's mixed-reality automotive design suite has been developed so that designers can get a feel for the car they are working on without waiting for prototypes to be built. Speaking with Epic, BMW remark that; "One of the big challenges in automotive design is finding the middle ground between crafting what a new car model would look like in a perfect world and what is possible from a manufacturing and production standpoint. Using a mixed reality design experience with Unreal Engine, VR, and specialised cutaway elements of physical car hardware, the team can experiment and make key decisions earlier in the design process" (Unreal Engine, 2020).

Walmart Virtual Reality Staff Training



FIGURE 10 - THE WALMART VR TRAINING SIMULATOR

Walmart has partnered with a company called STRIVR to bring VR training to Walmart's 200 training facilities located across America. The purpose of the VR training is to place employees in simulations where a customer problem becomes apparent; this helps employees who use it by conditioning them to aspects of their job before they even occur.

Speaking about the outcomes of the collaboration, STRIVR said that; "During the pilot, associates using VR training reported 30% higher employee satisfaction, scored higher on tests 70% of the time, and logged a 10 to 15% higher rate of knowledge retention than before VR. This pilot was so successful that Walmart decided to expand the program to all of its nearly 4,700 stores nationwide." (STRIVR, 2020).

As demonstrated with the examples above, the potential applications of game technology are far-reaching. For this project, product rendering will be done within a game engine. This is not to say the REM product configurator will be an application created entirely within a game engine. However, at the very least the task of product rendering will be allocated to a game engine rather than a traditional rendering suite like Autodesk 3DS Max. Below is a review of the potential game engines that could be used to produce photo-realistic product renders.

Unity 5



FIGURE 11 - THE UNITY GAME ENGINE

Released in June 2005 Unity is a cross-platform game engine that is programmed using C#. It has been used to create some of the most successful games of the last decade, games like Hearthstone, Monument Valley 2 and Ori and the Blind Forest (Unity, 2020).

Unity touts themselves as the engine of choice for the worlds game developers, on their company PR page they claim that they have recorded a 45% market share with developers worldwide, way ahead of the next largest market holder, Epics game engine Unreal Engine 4, which holds a 17% market share (Gamesparks.com, 2020).

Unreal Engine 4



FIGURE 12 - A REAL-TIME ANIMATION SCENE IN UNREAL ENGINE 4

Unreal Engine 4 is a popular game engine developed by Epic Games. Many AAA games like Fortnite and Rocket League use this engine. It features VR and AR capabilities out of the box. It comes with its very own visual scripting system called Blueprints, which make it easier for artists and hobbyist developers to program applications with relative ease (ConceptArtEmpire.com, 2020).

Cry Engine



FIGURE 13 - RYZE SON OF ROME, RENDERED IN CRYENGINE

CRYTEK develops the Cry Engine game engine, it was initially released in 2002, but since then has undergone five incremental engine expansions, making the "new" version Cry Engine 5. It is a cross-

platform game engine that features some of the best visual capabilities of any game engine. It is available for free to any developer (CryEngine.com, 2020).

Blender Eevee



FIGURE 14 - AN INTERIOR DESIGN SCENE RENDERED WITH BLENDER Eevee

The Eevee renderer inside of Blender is a new additional rendering engine implemented into the Blender application which provides users with the ability to render their scene in real-time as opposed to raytracing. It can be scripted using Python and interact with Blender's in-built game engine to produce interactive 3D scenes. One of the biggest changes that Eevee has provided is access to physically-based shaders (PBR) in Blender, which makes it one of the first non-game engine rendering solutions to feature such an implementation.

This decision comes down to two game engines, Unity and Unreal Engine 4. Both have excellent inclusions of virtual and augmented reality technologies and both feature what would be considered photo-realistic rendering engines. However, going back to Chapter 2.1, REM has specified that they wanted the solution to be trainable to someone with minimal effort. So, with that in mind, Unreal Engine 4 has the advantage. The fact that it features a visual scripting system as a core part of the engine makes programming and data structures more accessible. So from REM's perspective, it would be easier to train someone in Blueprint scripting rather than coding traditional C# in Unity. Unity does have addons and plugins that bolt-on visual scripting functionality, but these features are not officially supported by Unity. So adopting these additions creates extra dependencies where there need not be any. In terms of rendering capabilities, there are very few differences between the two-game engines. With enough work, either engine could produce photo-realistic product renders. Both engines are available for businesses to use, but Unity comes with a cost, and Unreal Engine 4 does not, albeit a small difference in the scope of the undertaking of this project, it is a difference, and it is an overhead that is needlessly encumbering. Cry Engine is a powerful rendering solution, but the documentation surrounding its use is too complex to hope that REM would be able to train someone who is not already

a professional in Cry Engine development. Blenders EEVEE inclusion is an excellent addition to the platform. However, its programming capabilities are not sophisticated enough to develop a complex project. On review, Unreal Engine 4 is the game engine that this project will use for creating product renders.

2.4. TRADITIONAL RENDERING METHODS

Traditional rendering methods refers to a suite of applications that have been predominantly used in the past to complete certain tasks. In this case, the task being referred to is product rendering. In previous generations, game engines could not achieve comparable quality with other rendering solutions available commercially. These solutions are called CPU renderers, as the calculations for rendering in these applications takes place on the CPU. Game engines predominantly use the GPU to calculate their renders. So, this is an apt distinction. CPU renderers typically use raytracing to calculate global illumination, shadows and reflections. Due to the high level of calculations required, this cannot happen at run-time. So, while these applications are rendering engines; they are not real-time rendering engines.

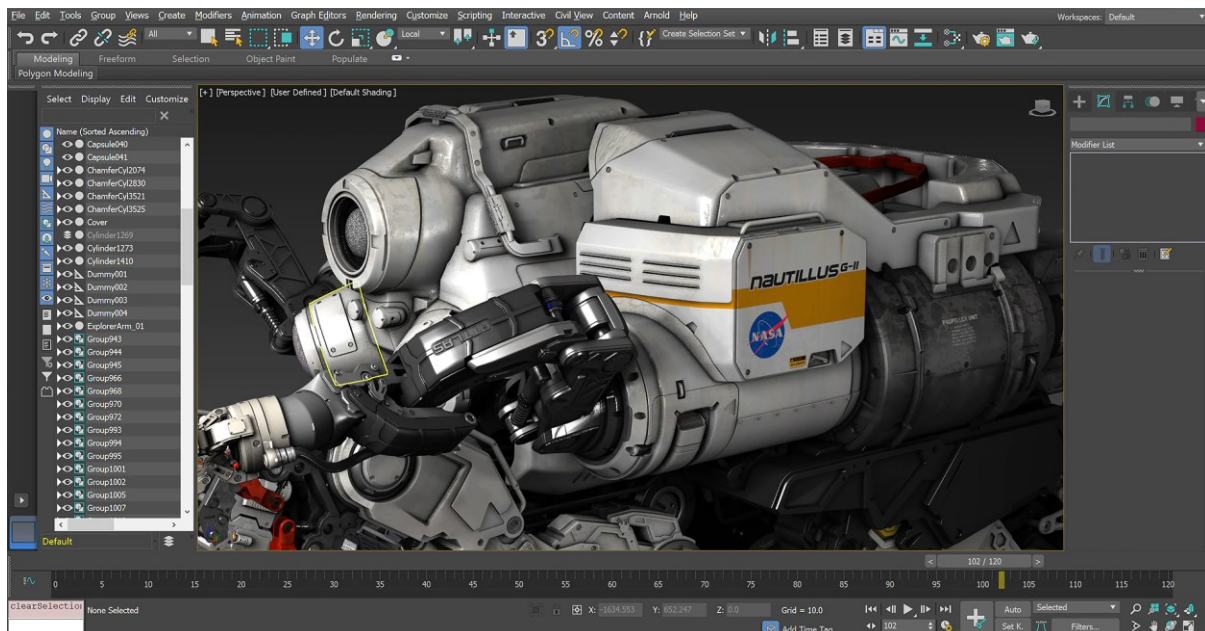


FIGURE 15 - THE AUTODESK 3DS MAX 3D RENDERING ENGINE

Traditionally CPU renderers have been used in any task that required computer graphics. The film, architecture, media and ironically games industries used CPU renderers to generate high-end computer graphics. It is only in recent history that computer game engines have been capable of competing with the quality produced from CPU renderers. However, now that game engines can compete in some cases, the decision of which type of renderer to use has become unclear. Given the advent of certain inclusions in game engines, for instance, animation, real-time weather effects, user interactivity with the scene, the justification for using a CPU renderer over a game engine must now happen on a case by case basis.

3. HYPOTHESIS

The question that this project is asking is; will using game technology in the development of a product configurator brings with it many advantages that traditional rendering methods lack? Game technology – more specifically game engines, bring with them a plethora of tools that applications like Autodesk 3DS Max do not feature. This is an inherent part of them being different products. However, the essence of what will be explored in this project is the exploitation of the advantages that game technology brings. Advantages are by definition the identification that something about an entity is superior to the analogous attribute featured in another entity, but the establishment of just how large or small these advantages are; is far more informative than the identification of the advantage in and of itself.

Game engines can be manipulated and changed dependant on the desired outcomes. Applications like Autodesk 3DS such as Autodesk 3DS Max and Blender, cannot be changed in any meaningful way, which means that game engines can be tailored to the tasks involved in creating a product configurator far better than an off-the-shelf solution. A game engine that has been programmed to render images of products automatically will be much faster than a traditional rendering solution and will likely be able to complete tasks that a traditional rendering solution cannot assist with at all. Once exploited, this advantage will prove decisive in answering the research question posed by this project.

4. AIM

This project aims to develop a product configurator for REM that assists in the sale of their products and can be implemented seamlessly with their business model. It must follow a set of requirements that have been established by REM, these requirements are;

- Updating the product configurator with annual changes can take no longer than two-months.
- Once developed, it must be available for REM's wholesalers to use across the country.
- It must feature every product in every single combination.
- One person must develop it.
- It must be available to use on PC, tablet and mobile.
- It must be ready for release by July 2019.

To create this product configurator, and meet REM's requirements, the project will utilize game technology with the explicit intention being to automate certain tasks involved in development. These tasks will be;

- Rendering product images.
- Storing these images in a library.
- Labelling these images.

Once developed, the product configurator will be released to the public. If it produces enhanced commercial outcomes for REM, and the development of the project can be proven to have taken less time and resources than its proposed counterpart, then the project will be considered a success.

5. MATERIALS AND METHODOLOGY

This chapter will explain the work conducted in the project from the start of development through to the end; it will include what materials were used and how they were used in development.

5.1. REM PRODUCTS OVERVIEW

REM has 144 products available for sale, only 111 of these products feature elements that are configurable. 67 products are exclusively laminate-based, 36 are exclusively fabric-based, and 8 products feature both laminate and fabric materials. Every configurable product is available in 20 different material finishes, regardless of whether its laminate, fabric or both. Additionally, each product comes with up to 3 optional components.

The main selling point of REM products is the colour element system. It is a simple system that allows customers to mix and match different material finishes on different sections of a product. The areas for customer choice in this system are denoted using alphabetical characters, for instance, if a product features two colour elements, it will have a colour element A and a colour element B. Each colour element refers to a section of the product available for customisation. Below is an example of how this system is presented to customers.

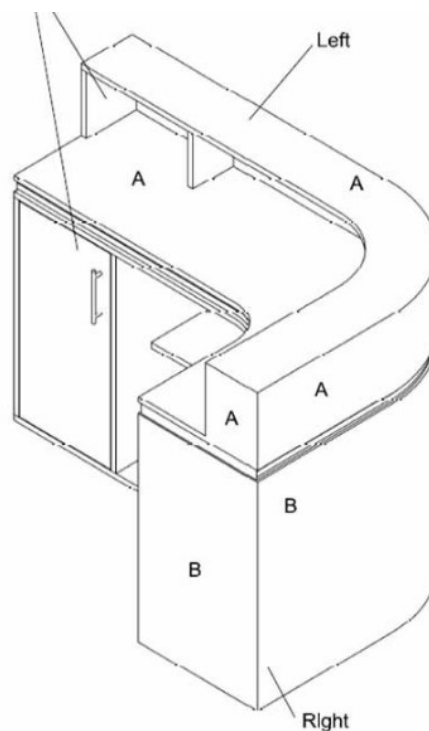


FIGURE 16 - A DRAWING OF THE "SATURN DESK 4X3" DENOTED WITH ITS COLOUR ELEMENTS "A" AND "B."

Another important aspect of REM products is that the material finishes are all specifically positioned and have predefined directions, for instance, on the Saturn desk featured in Figure 8, the wood grain on every panel runs horizontally and not vertically, but there are exceptions to this rule. The decision making of these specifications is not systematic, its arbitrary, but once a decision is made, it doesn't change. Every single Saturn desk features this same specific finish. It is something that customers expect to be correct, so it needs to be reflected in the product configurator. This means that each panel of every product will have to be directed, scaled and positioned correctly on its UV map to ensure that it reflects its real-world counterpart.

5.2. RENDERING SYSTEM DESIGN OVERVIEW

Conceptually, the primary ability the rendering system need's is the ability to render an image of a product with relatively photo-realistic results. This system would also have access to all the configurable elements of a product so that they can be modified at run-time. The system would then run a process which would sequentially run through products available customisation values and render off an image for each iteration. The rendered image would then be uniquely earmarked and stored in a specific manner so that a user can retrieve them in an orderly fashion.

When developing a product configurator, one of the biggest problems to tackle is how to accurately describe a products current configuration in simple terms. The importance of this problem scales with the scope of choice available in the product range. To address this problem, a theoretical system was created called "Render Codes". Render codes are a reference system that assigns character values to a user's choices and then concatenates these characters to create a singular string value. This string value is unique and references a specific product in a specific configuration. An example of a render code can be found below;

123-ABCD-101

FIGURE 17 - AN EXAMPLE OF A RENDER CODE

The first section of the render code describes the identity of a product. This is denoted using a 3-digit value, which is called a product's "Global Index". Currently, it is generated by indexing the position of the product in the REM 2018 catalogue, but fundamentally it's an arbitrary value, it could be based on anything that sets products apart from one another. The second section of the render code is called the "Material Hash", it denotes the current material choices featured on a product. These choices are represented by using four alphabetical characters that each represent a different material from the REM 2018 catalogue. As the current amount of material finishes available on REM products is 20, the alphabetical characters used in this system are "A" through "T". The index position of each material hash character represents a colour element and mirrors its position, for instance, the first character of the material hash represents colour element A, the second character represents colour element B and so forth. The tables below show the character values used to represent for both fabric and laminate material choices.

Normal Array Index Value	New Custom Index Value	Laminate Material
0	A	White
1	B	Black
2	C	Pillow Pink
3	D	Sea Breeze
4	E	Dove
5	F	Aubergine
6	G	Titanium
7	H	Egyptian Gold
8	I	Alu Brosse
9	J	Pewter
10	K	Cherry Wood
11	L	Rustic Oak
12	M	Pasadena Pine

13	N	Rich Praline
14	O	Michigan Elm
15	P	Bonobo
16	Q	Dusk
17	R	Dawn
18	S	Reed
19	T	Flagstone

TABLE 2 - CHARACTER VALUES FOR REM LAMINATE MATERIAL CHOICES

Normal Array Index Value	New Custom Index Value	Fabric Material
0	A	White
1	B	Bison
2	C	Tailored Clay
3	D	Tailored Vanilla
4	E	Galaxy
5	F	Black
6	G	Truffle
7	H	Pearl
8	I	Aubergine
9	J	Saffron
10	K	Coco
11	L	Tailored Slate
12	M	Platin
13	N	Tailored Putty
14	O	Phantom
15	P	Buffalo
16	Q	Kirsche
17	R	Fern
18	S	Tailored Ebony
19	T	Pebble

TABLE 3 - CHARACTER VALUES FOR REM FABRIC MATERIAL CHOICES

The third section of a render code represents the choices involved in selecting the optional components of a product. These choices are denoted by a binary value (0, 1) with “0” representing a “No” choice and a “1” representing a “Yes” choice.

Conceptually the rendering system would use a render code in two different ways; firstly a user could input a render code to generate a specific render or view a specific product and secondly once a user has selected a series of choices in the product configurator, the method of communicating the choices made back to the user would be in the form of a render code. This way, the data structure of the rendering system would be streamlined to a single variable. The rendering system algorithm for utilising a render code would start once a render code has been input. Once the system receives this input, it would break the render code down into three different sections, mirroring the methodology used to create it, at this point the algorithm would have values that point to;

- The product which needs to be rendered.
- What materials are featured on this product

- Where these materials are applied to the product
- Which additional options are active or not.

The Rendering Algorithm

Stage one of the algorithm would cross-reference each sub-string value against an array or set of possible outcomes. For instance, to discover which product needs to be rendered; the system would cross-reference the global index value against a “Product Array” that contained all the instances of products. Once completed, it would return a product instance which would contain all the mesh data that was needed to render the product, apply materials and switch components on or off.

Stage two of the algorithm would then cross-reference the material hash section of the render code against a laminate or fabric-based “Material Array”, this would then return a reference to the material that’s being applied to the product and the name of said material. Before this material is applied, the algorithm would check which colour element the character in the substring points to; this would be established by checking the index of the character in the material hash. Once this is complete, the system could then apply the correct material to the correct section of the product.

Stage three of the algorithm would pass the component reference to the product instance returned in stage one of this process. The product instance would then use this Boolean value in an IF statement to set the visibility of the mesh to either on or off.

Rendering Algorithm Automation

Once the functionality of this algorithm is complete, it could then be expanded into a larger system that could systematically render off every combination of every product without the need for user intervention or prompt. The way to achieve this would be to add an extra process to the core algorithm that would automatically generate render codes and then pass them to the rendering algorithm on a loop.

Rendering Algorithm Output

The third and final system that would be needed would automatically name, sort and store these renders in a library in an organized and predictable way. Theoretically rendering off every product in every combination would produce 100,000’s of images, so it is important that these images are stored using a simple structure that allows a user to intervene and update an image if there is a problem without much trouble.

5.3. 3D MODELLING

One of the largest tasks of the project was the create 3D models for all of REM's products. While technical drawings of these products did exist, they only existed in 2D and not 3D. Exporting these 2D drawings as 3D models created incomplete and overly complex geometry that could not be used in further production. As defined by (Lifewire, 2019), a 3D model is a mathematical representation of any three-dimensional object in a 3D software environment. Unlike a 2D image, 3D models can be viewed in specialized software suites from any angle and can be scaled, rotated, or freely modified. The process of creating and shaping a 3D model is known as 3D modelling. A 3D model is constructed from three different elements, vertices, edges and faces. Each of these elements plays a distinct role in describing a shape but creates cost when it comes to rendering. (Sciencing, 2019) defines a vertex as a mathematical word for a corner. Most geometrical shapes, whether two or three dimensional, possess vertices. For instance, a square has four vertices, which are its four corners. An edge is defined by (Mathopenref.com, 2019) is any geometric solid that is composed of flat surfaces an edge is a line segment where two such surfaces meet and a polygon. Faces in 3D modelling refer to any singular 2D surface of a model, these faces can themselves be many different shapes but normally take the form of polygons or triangles.

There are two types of 3D modelling methods that are used in commercial production; these types are distinct from each other due to the way in which they are constructed and modified, they are NURBS Surface modelling and Polygonal Modelling. A NURBS surface model can be defined as (Lifewire, 2019) a Non-uniform rational B-spline or NURBS surface is a smooth surface model created using Bezier curves. To form a NURBS surface, the artist draws two or more curves in 3D space, which can be manipulated by moving handles called control vertices (CVs) along the X, Y, or Z-axis. Polygonal Modelling is the most common form of a 3D modelling; they are constructs built of polygons, 4-sided faces that are organized in a precise and uniform fashion. Both types of these modelling techniques had to be used in the production of REM's product models. Hard surface products, like wood desks or tables, were created using Polygonal Models and fabric-based products like chairs, seating and stools were created using NURBS Surface modelling, specifically a sub-category of NURBS modelling called subdivision surface modelling. In total, there were 111 product models that had to be created in this project.

The first stage of modelling a product began with exporting it from AutoCAD. As previously stated, these exported assets were far too complex and costly to continue production but did offer a starting point for re-drawing. Once the exported product mesh was imported into Blender, it would then be manually re-drawn to reduce the complexity of the models' topology until it could not be simplified any more. Doing this would not only reduce the overheads required in rendering but would make UV mapping much easier later in production.

When the production had reached a stage where all the required elements were present on a product it was then split into different groups of geometry, for instance – all the chrome or metallic elements on the products were grouped together. Splitting a model into different geometric groups would increase the number of draw calls required to render it, in addition, it would also increase the number of material calls required, but it was a necessity to do this so that the objects created could be manipulated individually by the rendering solution.

NURBS products were produced using a different methodology; initial line drawings didn't exist, so another starting point needed to be created. A 3D scanner was used to capture topology data using an infrared depth sensor, while these captures were realistic, they were incomplete and contained holes in their topology where the camera couldn't capture, for instance underneath a chair seat or occluded objects. Once these captures were imported into Blender, subdivision surface modelling was used to recreate the topology. It's worth noting that the total cost of the geometry created for NURBS products far exceeded that of Polygonal products, this is naturally due to the shapes being described with NURBS products as much more complex than the simple line drawings featured in Polygonal products.

Once the topology had been successfully created for the NURBS product, it followed the same production methodology as Stage 3 of a Polygonal product. When this was completed, the product was ready for the next stage of production, which was to create a UV map for it using UV unwrapping.

5.4. UV MAPPING

Once a NURBS or Polygonal mesh had been created, and its geometric elements grouped, the next step was to unwrap it into a UV map. A UV map is the flat representation of the surface of a 3D model used to wrap textures easily. The process of creating a UV map is called UV unwrapping (Concept Art Empire, 2020). A UV map had to be created for each element of every single product. The starting point for UV mapping was that a product's geometric groups were UV unwrapped part by part and then laid out in random order on the UV map. At this point of production, the primary objective was just to get the panels laid out in 2D, the scale of the panels only became important once all the panels had been first unwrapped.



FIGURE 18 - A UV MAP PRIOR TO HAVING THE CORRECT DIRECTION, SCALE AND LOCATION ON THE LAMINATE APPLIED

The next stage of development was to ensure that any UV map created was representative of the real-world attributes that the product had. So panels were measured and adjusted accordingly using the one-metre material scans as a guide for sizing.



FIGURE 19 - A UV MAP AFTER HAVING THE CORRECT DIRECTION, SCALE AND LOCATION ON THE LAMINATE APPLIED

5.5. TEXTURES AND MATERIALS

Now that product geometry had been created and subsequently, UV unwrapped, the next stage in development was to create the textures and materials that would be applied to these objects. REM had up until this point, never attempted to create digital versions of its manufacturing materials, so work needed to be conducted in obtaining initial photography captures. In 2018 REM products featured 20 different laminate and fabric materials, each of these materials has both a colour and a texture property to it and so these properties needed to be captured using a diffuse texture and a normal map respectively.

The first step was to take a simple photograph of each material. This was done by creating 1-metre cut-outs of each material and then sliding them into a custom-built photography booth that was manufactured for the purposes of this project. The photography booth ensured that light was distributed evenly over the surface of the material and that the camera was centred and steady. Once a high-resolution photograph had been captured, the next stage in development was to clip the image so that it was framed correctly, and then to adjust contrast and brightness settings to make sure that the diffuse properties were apparent and balanced accordingly.

Diffuse Textures

A diffuse texture is the most common type of texture map. It defines the colour and pattern of an object. Mapping the diffuse colour is like painting an image on the surface of an object (Docs.cryengine.com, 2019). Diffuse textures were created by using the images taken in the photo booth and editing them in Adobe Photoshop, the aim here was to reduce the size of the image as much as possible while maintaining the quality of the image, the starting size of the images was 22mb, this was mainly due to the CR2 image format and the resolution of the image being 5760x5760px. Once the image format was changed to PNG and the resolution was changed to 3000x3000px the size of the images fell to 5mb or less, which was fine for the purposes of what they were going to be used for.

Normal Maps

Normal maps are a special kind of texture that allows surface detail such as bumps, grooves and scratches to be added to a model (Unity Technologies, 2019). Normal map textures were produced by taking the diffuse textures and imported them into a free “Normal Map Generator” which is available for use on any internet browser (Petry, 2020). The textures property of most REM materials is very slight, so once the values in the normal map generator reflected that the images were exported and were now ready for importation into Unreal Engine 4.

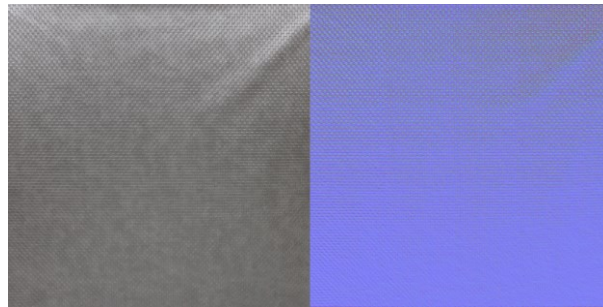


FIGURE 20 - THE MATERIAL "PHANTOM" DIFFUSE TEXTURE AND NORMAL MAP

Creating REM Materials in Unreal Engine 4

Now that both diffuse textures and normal maps have been created, the next stage is to create the materials that will be applied to meshes. The first step is to create the directory structure so that materials can be stored and returned in an orderly fashion. In the “Content” directory a folder called “Materials” is created, inside this folder, two more folders are created called “Laminate” and “Fabric”, these are the folders that the individual material directories will be created in. Once complete all the diffuse and normal textures created in previous stages can be imported into their own respective directories. The final materials were created by using the basic material asset in Unreal Engine 4. These materials take in the values “Base Colour” and “Normal”, with base colour being the node that the diffuse texture is plugged in to, and the normal node being where the normal map is plugged in to. Once this is complete, the material is ready to use.

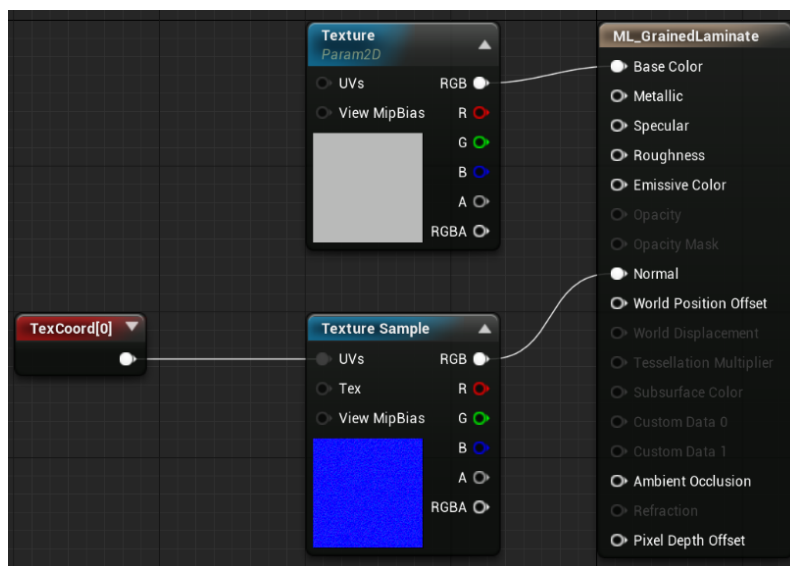


FIGURE 21 - REM MATERIAL STRUCTURE EXAMPLE

5.6. PROGRAMMING OVERVIEW IN UNREAL ENGINE 4

Programming in Unreal Engine 4 can take two different forms, C++ or Blueprints. This application will use blueprints, but several of the blueprint nodes used will be custom and will have been created using C++. A requirement of blueprint programming is that the applications data structure is bound within a predefined blueprint script hierarchy. There are two different levels of access within the hierarchy - global and local. Local blueprints only exist within the confines of the current level, for instance, objects within a level, player characters, NPC's and events. Global blueprints remain persistent throughout the applications session regardless of the level that is currently active. The diagram below represents the blueprint hierarchy's structure.

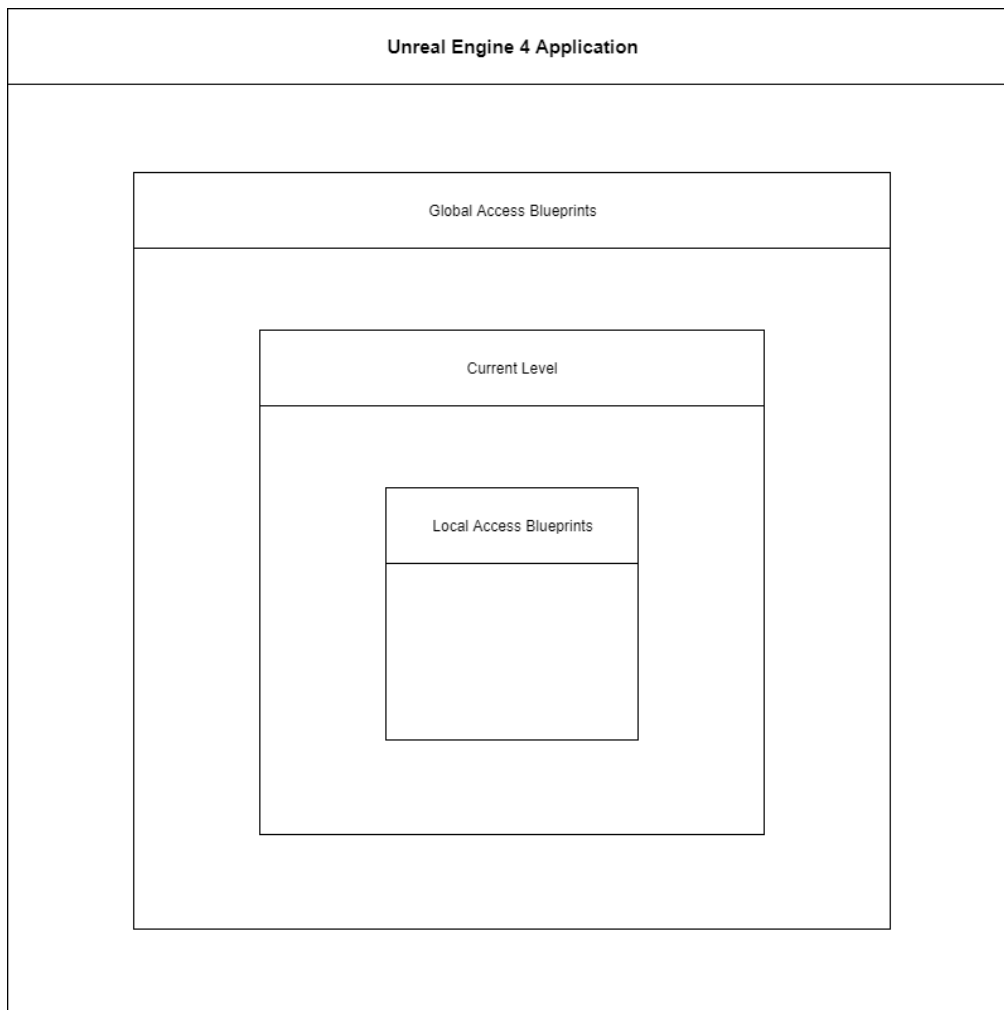


FIGURE 22 - THE BLUEPRINT SCRIPTING HIERARCHY

While both programming languages are featured in the rendering algorithms codebase, they are used to achieve different aims and objectives. C++ was used to modify Unreal Engine 4's source code to allow for different functions or classes to be created. In some cases, C++ was used to create custom blueprint nodes that contain functionality not featured in the standard blueprint toolkit. The application of blueprints specifically revolved around instantiating and modifying product instances.

Blueprint types can be understood more traditionally as another form of a programming class. The type of blueprint determines the scope and functionality that can be utilized using that type of blueprint. The standard toolkit of blueprint types that can be used in Unreal Engine 4 is unable to be modified. So,

if extra functionality is needed, or a new type of blueprint class needs to be defined – this happens by modifying the source code of Unreal Engine 4 using C++. Below is an explanation of the types and functionality of blueprints used in this project.

Game Instance

The game instance is a global access blueprint. This means that the data contained in this blueprint can be called on from anywhere else in the application's codebase. It's persistent – meaning that once it's loaded into memory at the application's initialization, it cannot be changed for another game instance. The global scope of this blueprint, alongside its persistency, means that most of the variables, arrays and data are placed inside this Blueprint.

Game Mode

The game mode blueprint is another type of global access blueprint, it's where gameplay values should be stored, for instance, scores, achievements, health etc. The niche functionality of a game mode blueprint is that it can be swapped out for another game mode at run-time. This allows gameplay specific structures to be defined inside their own specific game mode blueprints and then, if needed, be swapped around at run-time. An example of this would be a game that combined multiple game types, for instance, a game that at its core was a 2D platformer, but also featured first-person shooter elements at some points could utilize a game mode blueprint for the 2D platformer aspects of the game, and then switch to a first-person shooter game mode blueprint when required. This allows for easy and effective object-orientation shifts between different types of gameplay at run-time.

Player Controller

The player controller blueprint is a global access blueprint that focuses on the user's interactions in the game. Inside this blueprint, you would place all your functions to define player specific capabilities in the software, for instance – jumping, run speed, crouching, what happens on button presses etc.

Structures

Structure blueprints are used to define data objects to assist with object-oriented programming.

Actors

Actor blueprints are quite simply assets in a game that can be interacted with or modified at run-time. An actor blueprint allows you to define how these entities behave and the conditions required for their behaviour.

5.7. INSTANTIATING THE RENDER CODE SYSTEM

As discussed in Chapter 5.2, one of the core features of the rendering application revolves around the use of a reference system called render codes that would efficiently communicate all the information needed to render a product correctly. This system is implemented solely in the game instance blueprint, a global level script that can be accessed from anywhere else in the application. The first step in instantiation is to create the string variables needed for the render code system, these variables are;

- Current Render Code (String)
- Global Index (String)
- Material Hash (String)
- Component Values (String)

Once these values have been created, the next step is to create a function that will break down a render code input into its three elements. This is also done in the game instance blueprint so that the function can be called from anywhere else in the application. The functions name is “Render Code Refresh”. Below is the blueprint script;

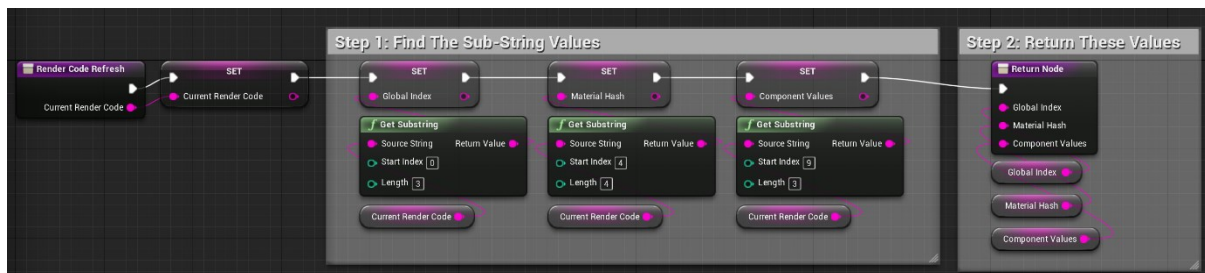


FIGURE 23 - THE RENDER CODE REFRESH BLUEPRINT SCRIPT

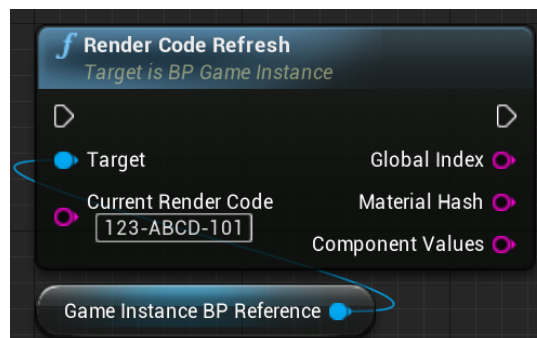


FIGURE 24 - THE BLUEPRINT NODE FOR RENDER CODE REFRESH

The function uses the “Get Substring” node to return values from the input string. The only other values that need to be declared before run-time is the starting index of the return in the input string and the length of the sub-string being returned. Once the string has been broken down into its separate values, these values are then returned so that they can be used elsewhere in the application. For the purposes of development, the string input will be manually entered until the rendering algorithm is complete. Once the rendering algorithm is complete, the next stage of development will be to automate the input of render codes.

5.8. CREATING THE MATERIAL ARRAY SYSTEM

REM materials will be a persistent element of the product configurator, and so they need to be stored in the game instance blueprint. As mentioned previously in Chapter 5.2, these arrays need to feature a character index rather than a numeric index. The array contains two aspects, a custom object that defines what a material structure is, and a map that links a character value to a material structure. Material structures are defined by two variables, a "Material Name" and a Material Instance" reference. The material name is simply its generic name, and the material instance reference is the directory location of one of the materials created in Chapter 5.5 the name of this new object is "S_Material".



FIGURE 25 - THE MATERIAL STRUCTURE CALLED "S_MATERIAL"

Once material structures have been defined, the next stage is to create the data map, a data map is a custom array that allows two different types of data to be linked. In this case, a string value is mapped to a material structure value. Once created, the next step is to fill the arrays with their respective content, using the tables in Chapter 5.2 as a guide.

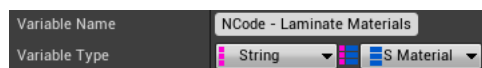


Figure 26 - Laminate materials Array map

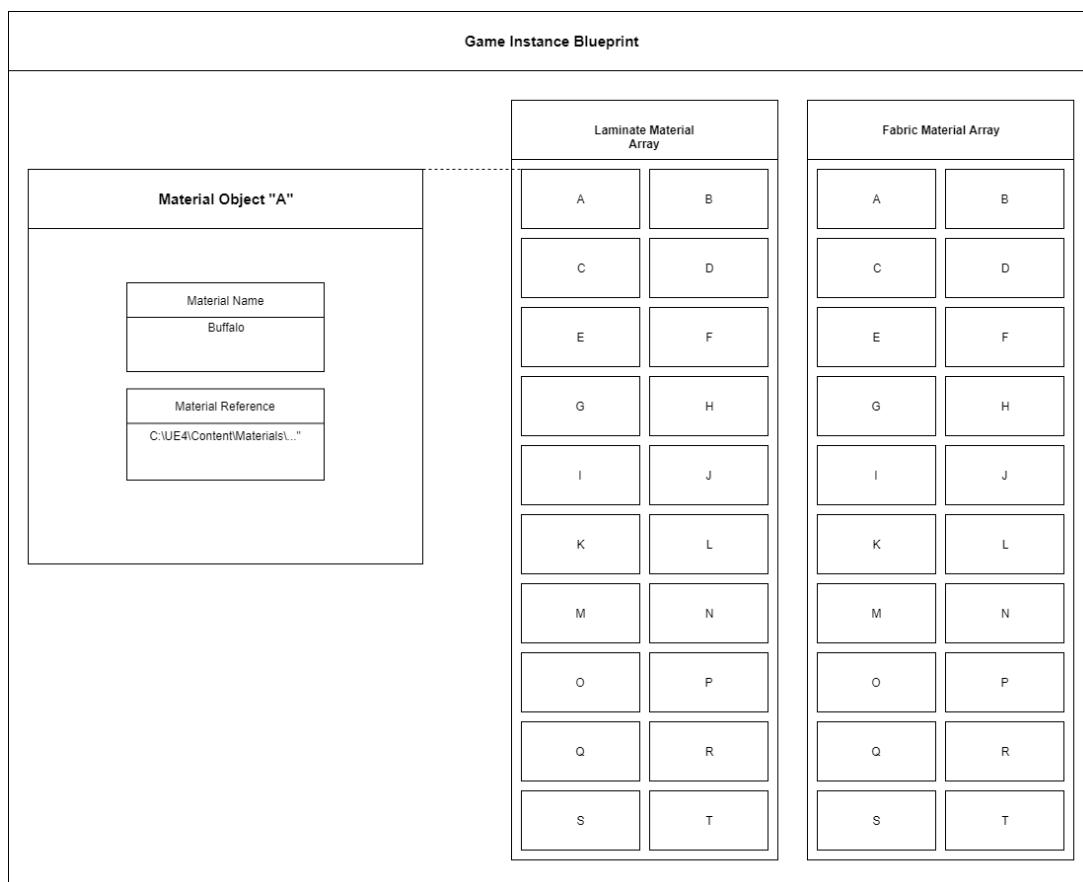


FIGURE 27 – STRUCTURE OF BOTH MATERIAL ARRAYS IN THE GAME INSTANCE BLUEPRINT

5.9. RETURNING VALUES FROM THE MATERIAL ARRAYS

Now that the material arrays have been populated with the material instances created in Chapter 5.5 the next stage of development is to create the functionality required to return a value from one of these arrays using the render code refresh function created in Chapter 5.8 alongside a new function called the “Find Material” function, two versions of this function exist, one for returning laminate materials, the other for returning fabric materials. These functions needed to be independent of one another due to some products, as outlined in Chapter 5.1, having both laminate and fabric elements. The first stage in development is to create a new set of string variables, these values are;

- Render Code A (String)
- Render Code B (String)
- Render Code C (String)
- Render Code D (String)

These variables will hold the separate values broken down from the material hash variable as outlined in Chapter 5.2 Once all the variable values have been set, they are then cross-referenced against the “Laminate Materials” array created in Chapter 5.9 to return a material instance value.

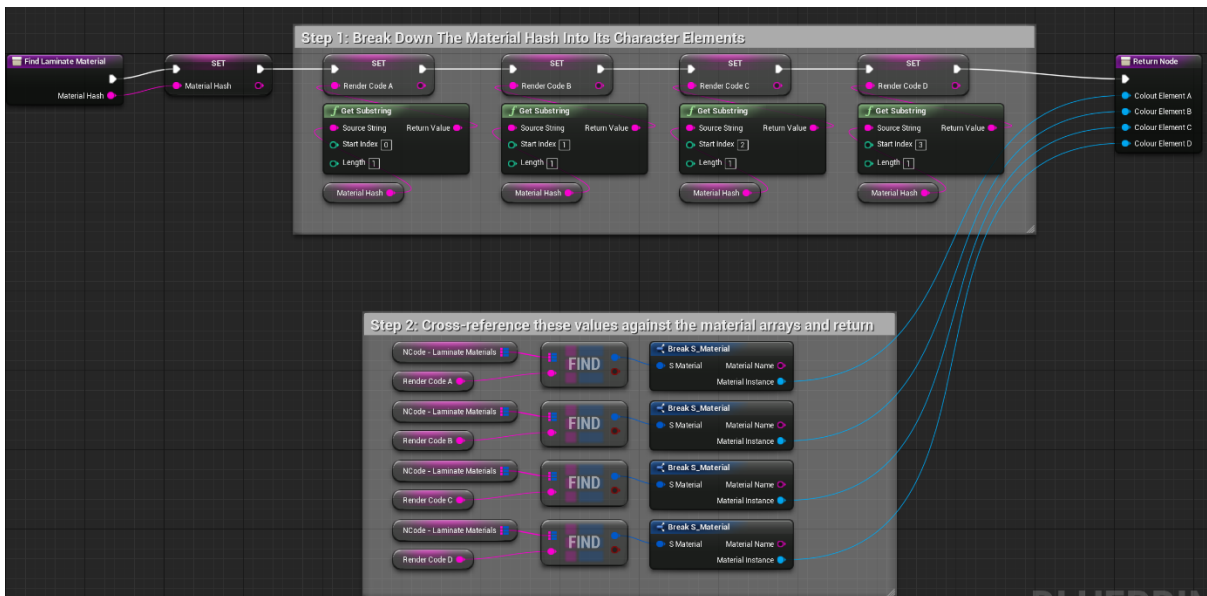


FIGURE 28 - THE "FIND LAMINATE MATERIAL" BLUEPRINT SCRIPT

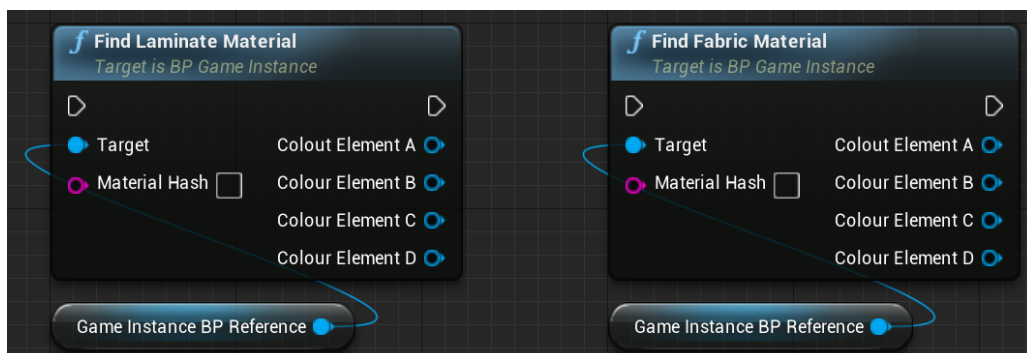


FIGURE 29 - THE "FIND LAMINATE MATERIAL" AND "FIND FABRIC MATERIAL" BLUEPRINT NODES

5.10. STORING PRODUCT DATA

Now that product instances exist, data that are intrinsic to each individual product must be stored inside a blueprint, the data that would be most useful to store would be;

- Global Index
- The colour elements that are featured on the product

All this data can be stored in the game instance blueprint using a function called “Prepare Product”, this function is called on the initiation of the application and is not editable at run-time. The first step in creating this function was to create the variables that it uses. These variables were created in the game instance blueprint. Specifically, the variables are;

- Global Index (String)
- Has Element A? (Boolean)
- Has Element B? (Boolean)
- Has Element C? (Boolean)
- Has Element D? (Boolean)

A product name was not included due to the nature of only one variable being needed that uniquely identifies products, so it was a redundancy in the data structure.

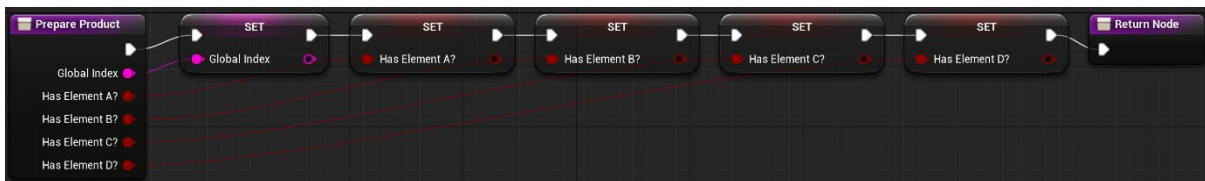


FIGURE 30 - THE PREPARE PRODUCT BLUEPRINT SCRIPT



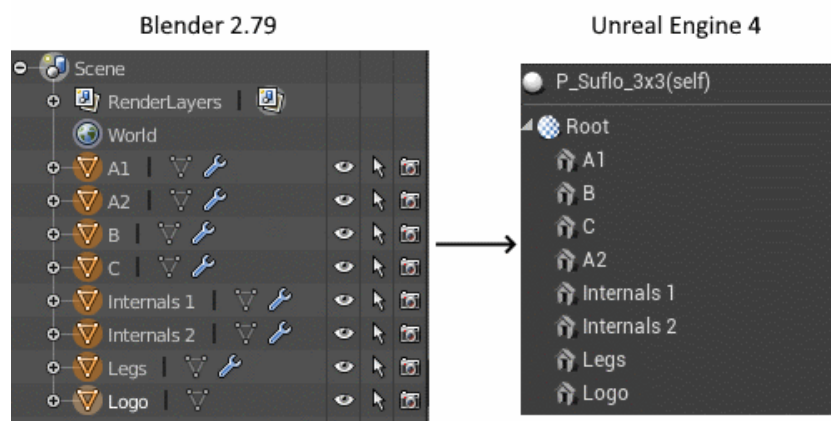
FIGURE 31 - THE PREPARE PRODUCT BLUEPRINT NODE

The global index value, as mentioned in Chapter 5.2, is the unique identifier for a product. The other four Boolean values represent if the product features a colour element type. The knowledge of whether a product features a colour element or not will become useful later in development when the rendering algorithm is being created. Knowing whether a product has a colour element or not allows the rendering algorithm to continue or exit at the appropriate point.

5.11. CREATING PRODUCT INSTANCES

Now that all the different functions and assets have been created for products. Work can now be conducted on bringing all these features together in a product instance blueprint. The example used in this explanation is the Suflo 3x3 Desk, but the same work is replicated for all product instances outside of setting the individual values that each product possesses. Firstly, an actor blueprint is created, these blueprints are local level scripts but can be manipulated at run-time, unlike the game instance blueprint or other global level blueprints. Once created the actor blueprint is named “P_Suflo3x3”.

Once the actor blueprint for the product has been created the next stage is to add the 3D models created for the Suflo Desk 3x3 in Chapter 5.3 these models have already been imported into Unreal Engine 4, so the only task left is to add them to the product instance blueprint using a static mesh component. A static mesh component is essentially a container for any 3D model that you wish to use in a blueprint. Once you add a static mesh component to a blueprint, you can give it a name and then select which 3D model you want it to display from the content directory. Since all the model groupings have already been defined in Chapter 5.2, a static mesh component needs to be added for each model group, for simple continuity purposes these components were given the same name as the model groups had in Blender.



The next stage of developing product instance blueprints focused on creating access to the data stored in the game instance blueprint, this was done by creating a game instance blueprint reference. A value was also creating in the game instance blueprint, which parameterized the value of a product instance. Since there is only one product instance per level, once the level starts the product instance inside of the level sets itself as the current product instance in use, this is so that the rendering algorithm can easily identify which actor in the level is the product instance. These declarations all happen when the application starts; in blueprints, this event is known as the event “BeginPlay”. Once complete the final function to add to this event is the function created in Chapter 5.10 “Prepare Product”, once created the function is populated with the corrects values for the Suflo Desk 3x3.

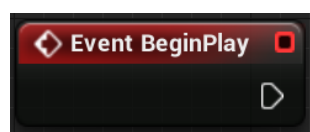


FIGURE 32 - THE EVENT BEGIN BLUEPRINT NODE

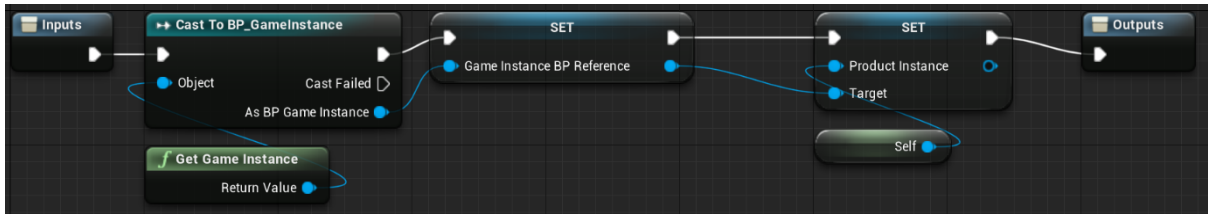


FIGURE 33 - THE GAME INSTANCE REFERENCE AND PRODUCT INSTANCE VARIABLE BEING DECLARED

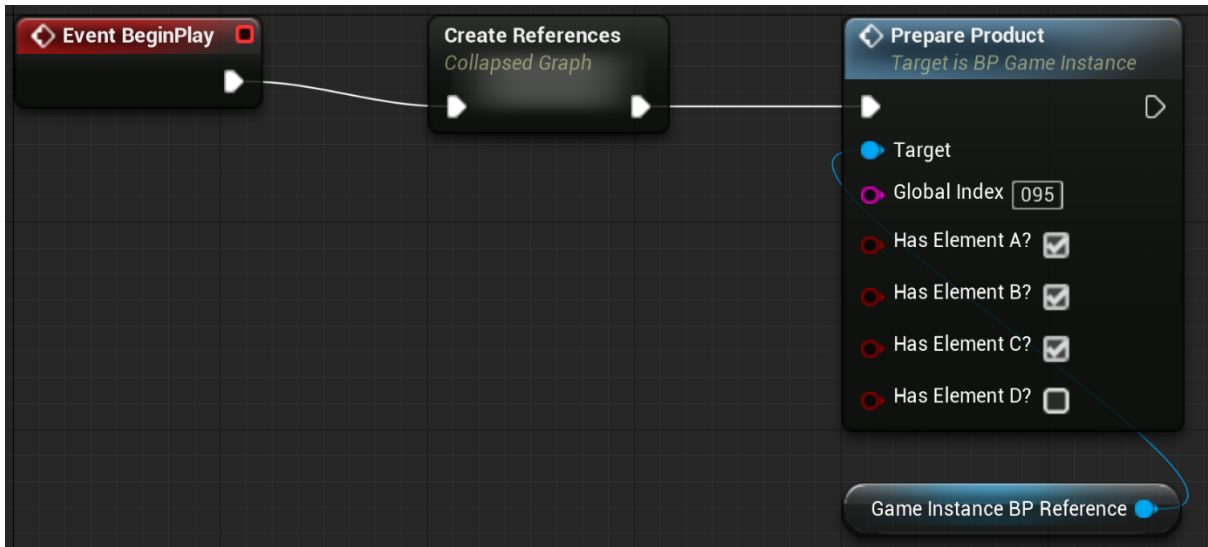


FIGURE 34 - THE EVENT BEGIN FUNCTIONS INSIDE A PRODUCT INSTANCE BLUEPRINT

The main functionality of a product instance blueprint is its ability to reconstruct itself, whether that be the materials that it features or the mesh components that its displaying, to do this a custom event must be created that will trigger this to happen. An event is created called “Refresh Current Product Instance”, this event can only be called by the player in the “Player Controller” blueprint. The player controller blueprint is a global level blueprint which typically contains all the events and functions linked to a player’s actions in a game, for instance, movement, keystrokes and controller input. The rendering algorithm will be initiated by a keystroke, and so the event that triggers product instance blueprints to update themselves must come from the same blueprint.

The first function to link to the refresh current product instance event is the “Render Code Refresh” function created in Chapter 5.7 as previously explained this function processes the current render code so that other functions can utilize it. Since the Suflo Desk 3x3 is a laminate-based product, the next function that needs to be added is the “Find Laminate Material” function. This function will return materials from the material arrays created in Chapter 5.8 based on the outputs of the previous function. The final functions to add are the “Set Material” blueprints nodes that will apply the materials returned by the previous function to a user-defined selected of static mesh components. Due to this product featuring three colour elements, there will need to be three set material blueprint nodes. Each one of these blueprint nodes will deal with the material changes on a singular colour element. The static mesh components that are used by these blueprint nodes have already been created and declared at the start of this chapter, and so all that needs to be done is to structure this blueprint graph accordingly.

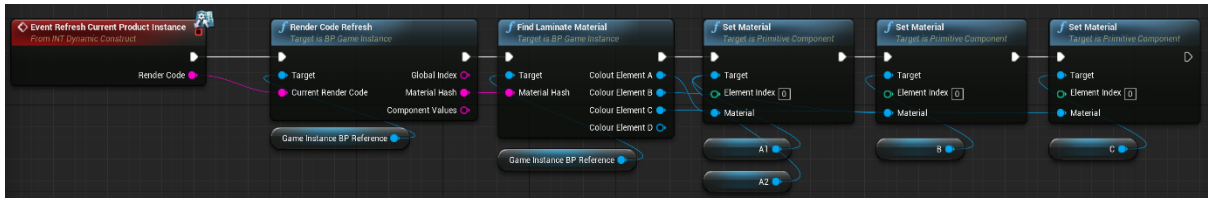


FIGURE 35 - THE EVENT REFRESH CURRENT PRODUCT INSTANCE AND ITS FUNCTIONS

The final functionality the product instance blueprint needs is the ability to toggle the visibility of the static mesh components involved in a specific colour element at run-time. This will allow the rendering algorithm to render images for each colour element individually. To do this another set of custom events were created in the player controller blueprint. Specifically, these events were;

- Render Only A (Event)
- Render Only B (Event)
- Render Only C (Event)
- Render Only D (Event)

One of each of these events was created inside the product instance blueprint, and the static mesh components associated with the colour element were linked to a “Set Render Custom Depth” blueprint node. This blueprint node can toggle the render depth value on any static mesh component on or off, doing so toggles the visibility of the static mesh component on or off.

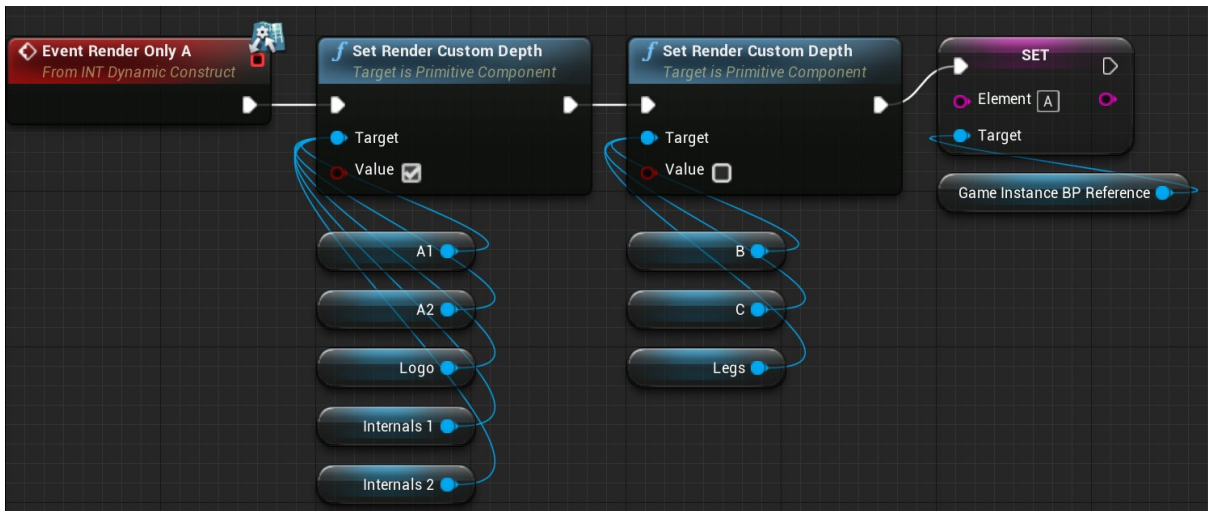


FIGURE 36 - THE EVENT RENDER ONLY A AND THE RENDER CUSTOM DEPTH FUNCTIONS

The last element to add to a product instance blueprint is adding a value to the game instance simply called “Element” this value is used to track which colour element the product instance blueprint is currently displaying, allowing for the rendering algorithm to more easily switch between events. From here products instances are able to construct different product specifications; currently, only a single specification can be done at run-time, but this isn’t a limitation in the system, the only component that needs to be added for dynamic product specifications at run-time is the addition of a system that sends new render codes to the product instance for processing.

5.12. CREATING PRODUCT LEVELS

The next stage of development is to create the scenes that the product instances exist in. Scenes in Unreal Engine 4 are known as levels. The aim of the levels used in this project is to be digital versions of a product studio, a photography setup used to take high-quality pictures of commercial products. To achieve this, a photography scoop mesh is created with a floor so that a product instance can be placed on it. Once the studio meshes were in place, the next stage was to place a product instance on the floor. This location was always the same for every product due to the nature of the same studio scoop being used in every level.

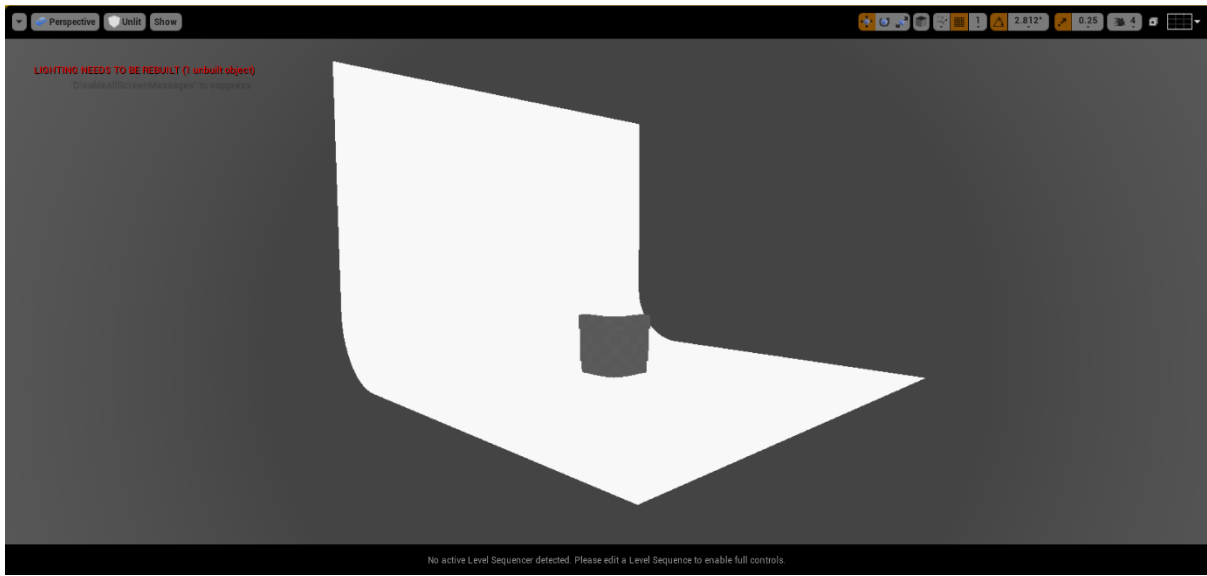


FIGURE 37 - THE PRODUCT STUDIO PRIOR TO LIGHTING BEING IMPLEMENTED

The next step is to create the levels lighting, all lighting used in this project is static, meaning that it is calculated prior to run-time. The specific placements of lights were arbitrary, and once a good level of lighting was achieved, they were generally left alone. Once complete lighting was baked.

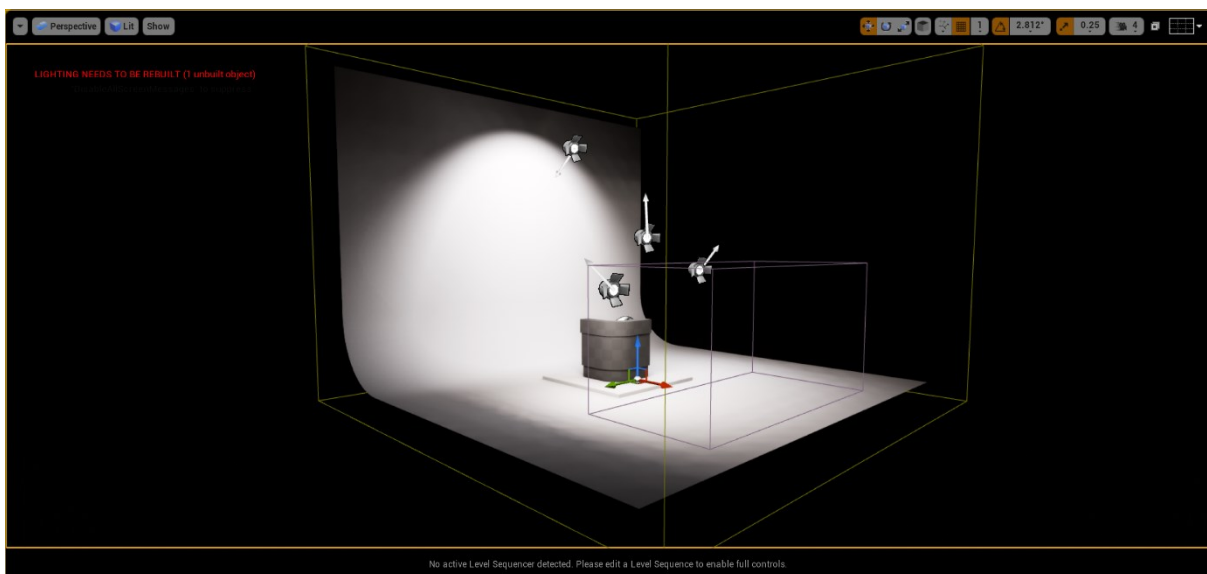


FIGURE 38 - THE PRODUCT STUDIO AFTER LIGHTING HAS BEEN ADDED AND BAKED

Once the studio was set up, the product instance was placed, and lighting was baked, the next stage was to add cameras to the level. Due to product instances, all being in the same location cameras were anchored to this location using a simple vector arm. The distance between the product and camera was dependant on the size of the product, but other than that the focal length, aperture and aspect ratio were all the same throughout all product levels.



FIGURE 39 - THE PRODUCT STUDIO WITH CAMERA CONTROL SET UP

The final element to add to the product levels was the post-processing volume; these volumes add effects such as anti-aliasing and depth of field to the level. The effects used in all the products levels were as follows;

- Ambient Occlusion
- Screen Percentage
- Screen Space Reflections



FIGURE 40 - THE FINAL OUTCOME OF THE PRODUCT STUDIO

5.13. C++ AND CUSTOM BLUEPRINT FUNCTIONALITY

While the functionality provided by Unreal Engine 4's standard blueprint and C++ libraries is high, the novelty of the rendering algorithm requires that some simple custom functionality be created. To do this, the open-source C++ source-code must be edited to create a custom blueprint function that will develop aspects of the engine that already exist. In Unreal Engine 4, certain tasks can be completed via an engine console. This console allows the user to toggle aspects of the engine on or off, gain access to the GPU profiler and various other abilities. One of those abilities is the request screenshot command. This command takes a screenshot of the current screen at a resolution multiplier of the user's choice. This is the function that will be used to form the basis of the custom screenshot blueprint node.

The functionality that this blueprint node must have is the ability to take a screenshot of the current screen at the displayed resolution. Once this is done, it will then earmark the image with a label that the user can define and then save the image to a directory that the user also defines. These two tasks are separate but can be done at the same time. Below is the C++ code used to create this functionality.

```
#include "MyBlueprintFunctionLibrary.h"
#include "Engine.h"

void UMyBlueprintFunctionLibrary::RequestScreenshot(const FString & InFilename, bool
bInShowUI, bool bAddFilenameSuffix)
{
    GEngine->AddOnScreenDebugMessage(-1, 5.0f, FColor::Yellow, TEXT("Requesting
screenshot")); // display message on window (to check that you are actually calling
the lines below)
    //FString fileName("C:/Users/niall/Desktop/RenderStudioscreenshot.png");
    FScreenshotRequest::RequestScreenshot(InFilename, false, false);
}
```

FIGURE 41 - THE C++ CODE USED TO CREATE THE CUSTOM REQUEST SCREENSHOT BLUEPRINT NODE

The functions name is "Request Screenshot", it uses the standard request screenshot console command normally used in the engine but modifies it so that the default pathway is now a variable that needs to be input via a string value and the command can be triggered by an in-game event.

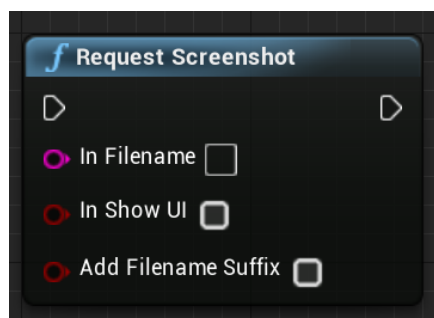


FIGURE 42 - THE REQUEST SCREENSHOT CUSTOM BLUEPRINT NODE

The request screenshot blueprint node is a fundamental necessity for the development of the rendering algorithm, as every time an image is needed, this function will be called. As discussed in Chapter 5.2, one of the goals of the rendering algorithm was to have it automatically save images in a systematic and predictable fashion. Now that this function exposes the directory value as a variable that is determined by the user, this objective can now be achieved.

5.14. THE RENDERING ALGORITHM

The rendering algorithm is the core component of the rendering solution. It uses all the elements created in previous chapters to systematically cycle through a product's potential combinations and render an image for each one. The rendering algorithm was created using the player controller blueprint. This was due to the player controller blueprint being reserved for actions that involved player interactions and the trigger for the rendering algorithm to start would be a key press by the user, specifically the spacebar. As explored in previous chapters the rendering system already has the ability to identify and execute a product's specification, but this can only be done by manually inputting the render code into the "Render Code Refresh" blueprint node displayed in Figure 27, which is featured in the product instance blueprint. The only new functionality that the rendering algorithm creates is the ability to cycle through a series of render codes which will be sent over to the product instance for processing during run-time.

The rendering algorithm can be explained in stages, below is a breakdown of the stages involved;

1. The user manually starts the application button by pressing the play button in the editor.
2. The user presses the spacebar key to start the process.
3. The "Render Only A" event featured in Chapter 5.11 is triggered in the product instance script.
4. A render code is sent to the product instance, starting with material A on colour element A.
5. Once executed, the "Request Screenshot" script featured in Chapter 5.13 is called.
6. An image is rendered with the name being based on the global index value input in Figure 26.
7. The image is then saved to a pre-defined directory (covered in Chapter 5.15)
8. The loop then increments and sends another render code for the next material; in this example, the next render loop increment would be material B on colour element A (XXX-BXXX-XXX).
9. Once the loop reaches material T, it then checks if there is another colour element featured on the product, this information is provided by the "Prepare Product" script featured in Figure 26 – if there is, then the event "Render Only B" in the product instance script is triggered.
10. This loop continues until it reaches material T on colour element D or the returned value for step 9 is false.

The render codes featured in this process are pulled from a pre-defined array. It's a simple string array that features 80 different render codes. The first value is XXX-AXXX-XXX; the second value is XXX-BXXX-XXX, and so on. The "X" values in the string indicate void values. So, the first 20 values of this array feature the same structure as the example given, moving through alphabetical character until it reaches "T". Once it reaches XXX-TXXX-XXX the next value in the array is XXX-XAXX-XXX, this value indicates that its rendering material A on colour element B. This same incremental structure is used for all 80 values finishing with render code XXX-XXXT-XXX and using the product instance blueprint created in Chapter 5.11 will create renders of every single product combination for any given product.

Once a rendering cycle is complete, the user can then set the active camera in the product level to the second camera for view 2 rendering and then starts the rendering algorithm again. Originally the rendering algorithm was set to automatically change cameras and continue rendering as part of the rendering cycle, but once the application started being used, users remarked that this created some redundancy when they needed to re-render images for a product.

5.15. RENDERING ALGORITHM IMAGE STORAGE

As the rendering algorithm loops, all images are sorted and deposited systematically into a logical, predictable folder system. Below is an explanation as to how these folders are sorted and what their contents are;

Level 1 – The REM Rendering Directory

The master directory that holds the entire library is named “REM Rendering” and is automatically created on the user’s desktop directory.

Level 2 – The Product Directory

This directory contains all the product folders – all being denoted by their name.

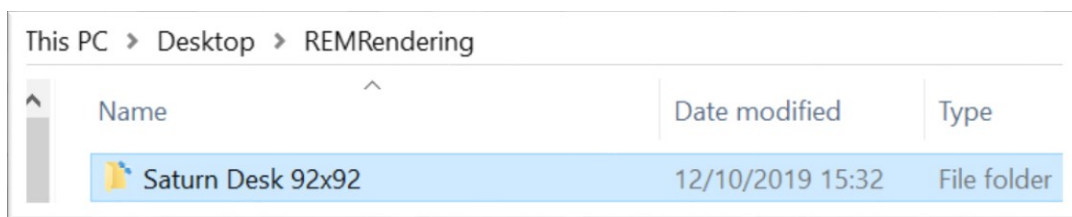


FIGURE 43 - THE PRODUCT DIRECTORY

Level 3 – The View Directory

This directory contains a folder for each product view, denoted as “View 1, and View 2”.

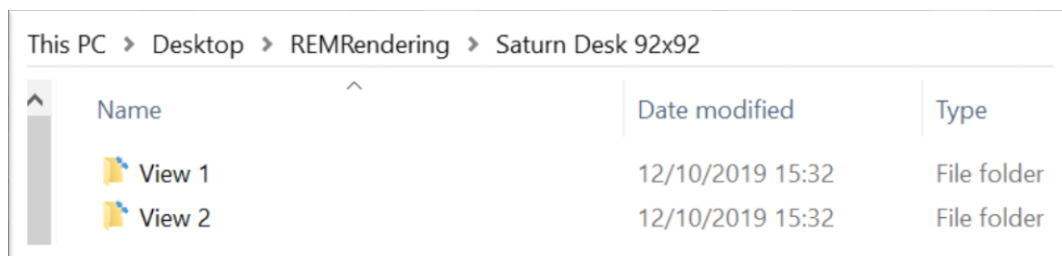


FIGURE 44 - THE VIEW DIRECTORY

Level 4 – The Colour Element Directory

This directory contains the colour element folders all denoted as their respective characters.

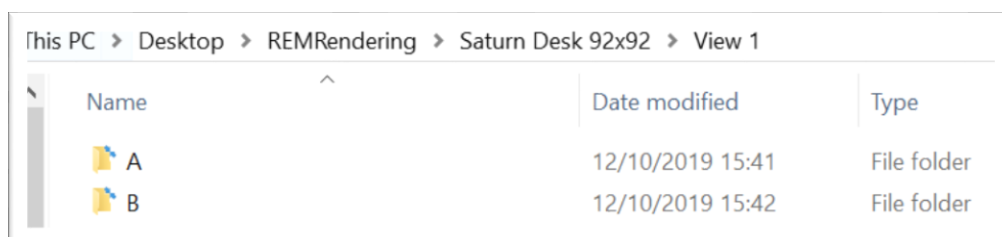


FIGURE 45 - THE COLOUR ELEMENT DIRECTORY

Level 5 – The Image Directory

This directory contains the actual product renders for that particular product, at that particular viewpoint, on that particular colour element.

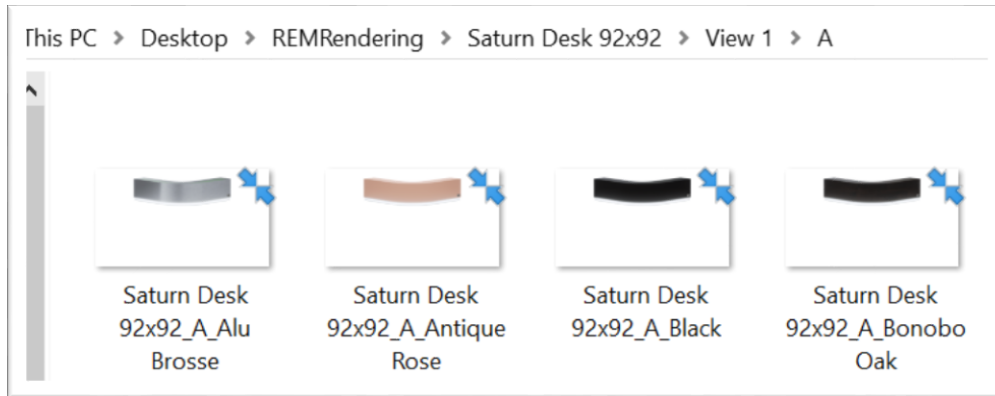


FIGURE 46 - THE IMAGE DIRECTORY

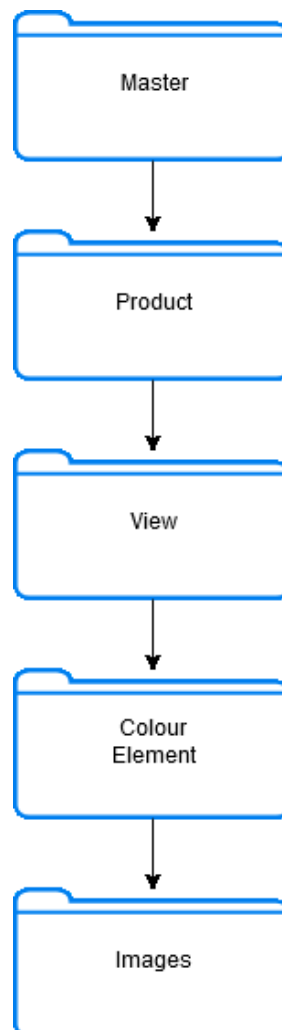





FIGURE 47 - THE FULL DIRECTORY PATHWAY FOR STORING IMAGES

5.16. THE WEB CONFIGURATOR

REM **SATURN DESK 3X3** GET QUOTE

CUSTOMISE FEATURES

Add a Cash Drawer?

YES **NO**

Add a Keyboard Slide?


YES **NO**

Add a Door Lock?


YES **NO**

CUSTOMISE COLOURS

Colour A - Pasadena Pine



Colour B - Rich Praline



The rendering algorithm can now create all the product images needed for a product configurator. The next stage of project development is to create the webpage which will use these images. As previously discussed, the target outcome of this project is a web-based product, visualisation configurator. REM's company website was developed using a platform called Wix, and so they requested that this project also use Wix for the development of this webpage. Wix is a cloud-based web development platform that uses a custom JavaScript API called Corvid, it doesn't provide as much development latitude as traditional web-stack languages but does provide a toolkit capable of developing simple event-based webpages (Wix, 2020).

The webpage will run dynamically, meaning that it loads the resources and data for each product only once the webpage has been initiated. To achieve this, a brief loading phase will be implemented on webpage initiation, which will provide enough time for the webpage to download the starting resources that it needs to initialize. The benefit of creating a dynamic webpage over a static version is that only a single webpage will need to be developed rather than a webpage for each product being added to the product configurator. As reviewed in Chapter 2.2, there are six design elements that typically composite a product configurator application, these design elements have been used as guidelines for the design of this webpage.

Product Orientation



FIGURE 49 – THE PRODUCT ORIENTATION BAR

Product orientation is the communication of which product the customer is currently modifying. Part of the intended outcomes of a product configurator is for it to reduce ambiguity and reduce selection errors, this makes the communication of the current active product and the edited components a foundational element of the webpage.

Product Visualisation



FIGURE 50 - AN EXAMPLE OF PRODUCT VISUALISATION OF THE SATURN DESK 3X3

The core component of any product visualisation configurator is the product visualizer. Its purpose is to clearly show what the product currently looks like given its current specification. As discussed in Chapter 2.2, the visualizer used in this webpage will use a stack of images to present the product visualisation. This group of images are all laid on top of one another accurately enough so that it creates the illusion of the group being a single image. A diagram indicating the structure and order of the image stack can be found below.

```
21     let currentView = 1
22
23     let view1_A
24     let view1_B
25     let view1_C
26     let view1_D
27
28     let view2_A
29     let view2_B
30     let view2_C
31     let view2_D
```

FIGURE 51 - THE VIEW VARIABLES BEING DECLARED IN THE CODEBASE

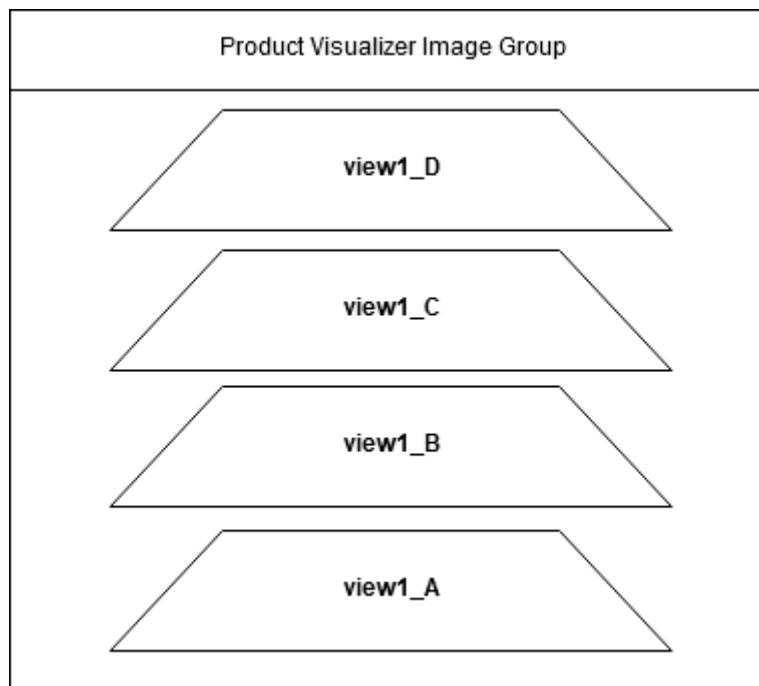


FIGURE 52 - A DIAGRAM DEMONSTRATING THE STRUCTURE OF THE PRODUCT VISUALIZER IMAGE GROUP

The dimensions of the product visualizer component are 960x540px; this is a specific size so that the product visualiser can be viewed in landscape orientation on a tablet device without any image clipping or scrolling being required. The resolution of the images used in the product visualizer is 1920x1080px, and all images are saved as PNG files so that the alpha channel (transparency) of the images is preserved. Any image used in the visualizer is downloaded on a user's selection, at runtime from a dedicated Wix database with a secure connection.

View Manipulation



FIGURE 53 - THE VIEW MANIPULATION COMPONENT BUTTONS

The view manipulation component is very simple; its purpose is to allow the user to view the same product from two different angles. All that is needed to do this are two buttons that each represents a viewing angle. Once a button is selected it triggers an event that forces the product visualizer component to refresh the images being used.

Geometry Manipulation

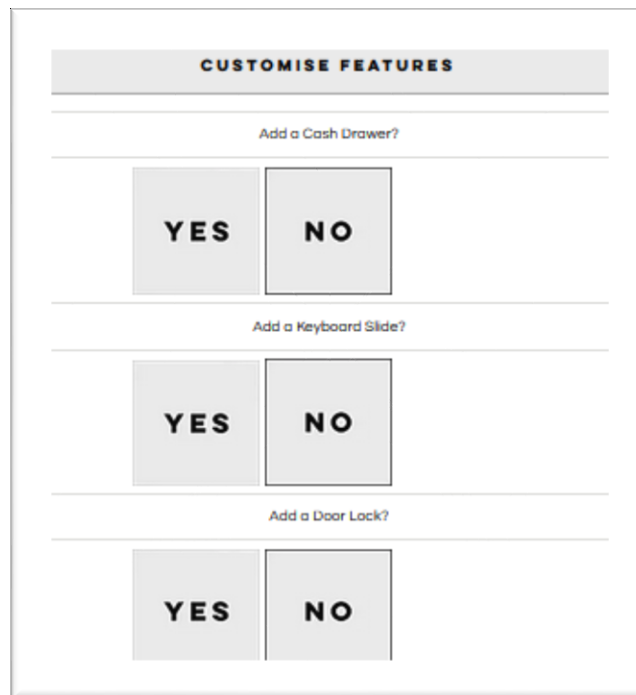


FIGURE 54 - THE GEOMETRY MANIPULATION BUTTONS

Since this webpage uses 2D images and not 3D models, the literal definition of what geometry manipulation does not apply. In this webpage, when a user selects to add or remove an optional component, an image is downloaded and is placed on top of the product visualizer image group which demonstrates what the component looks like. Unfortunately, the inclusion of this feature could not be carried into the product configurators release. REM decided that models used for rendering optional components were not reflective of their real-world counterparts, and with optional components being changed frequently, they felt that visualising one of these components would create more problems than it would solve.

Colour Manipulation

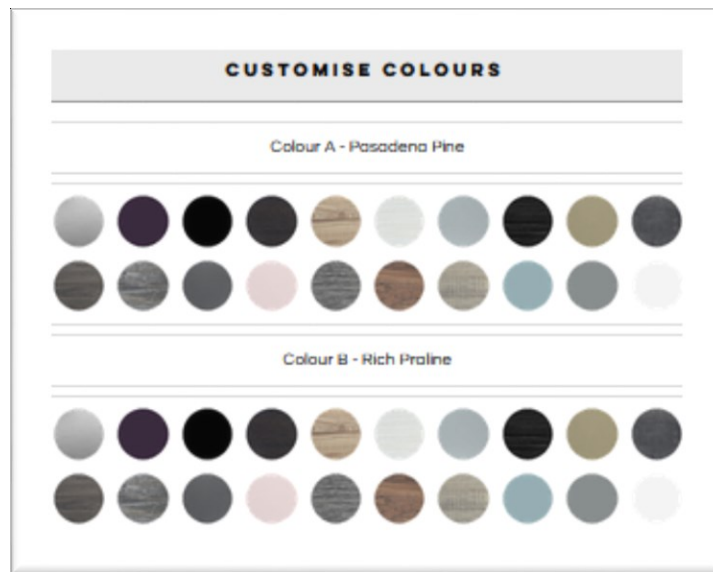


FIGURE 55 - THE COLOUR / MATERIAL CHOICE BUTTON PANELS

Colour manipulation is the simple ability to change colours on an object. As discussed, in Chapter 5.1, the REM colour element system defines the sections of products that are available for colour modification. Within each colour element, there are a pre-defined set of colours choices that the user can select from. The colour manipulation component reflects this structure. Embedding a button for each colour choice within a group defined by the colour element value.

```
109     export function AButton1_click(event) {
110         view1_A = $w("#dynamicDataset").getCurrentItem().view1_a_i
111         view2_A = $w("#dynamicDataset").getCurrentItem().view2_a_i
112
113         if ($w("#dynamicDataset").getCurrentItem().colourAType === "Laminate") {
114             $w("#laminataLabel").text = "Colour A - Alu Brosse"
115             Q_colourA_Choice = "Alu Brosse"
116         }
117         if ($w("#dynamicDataset").getCurrentItem().colourAType === "Fabric") {
118             $w("#laminataLabel").text = "Colour A - Aubergine"
119             Q_colourA_Choice = "Aubergine"
120         }
121
122         constructNewView()
123     }
```

FIGURE 56 - AN EXAMPLE OF ONE OF THE FUNCTIONS USED TO CHANGE COLOURS IN THE PRODUCT CONFIGURATOR

Each colour choice button within these groups has its own function in the codebase. When pressed the function triggers and a request is made to the database to return the image associated with that colour choice alongside its counterpart for view 2. Both of these images are set to values that indicate which part of the product visualizer image group they are. Once the images have been downloaded the functioned `constructNewView()` is called, which will refresh the product visualiser's image group, using these newly downloaded images. Once `constructNewView()` has executed the visualiser's image group will reflect the choice that the user made.

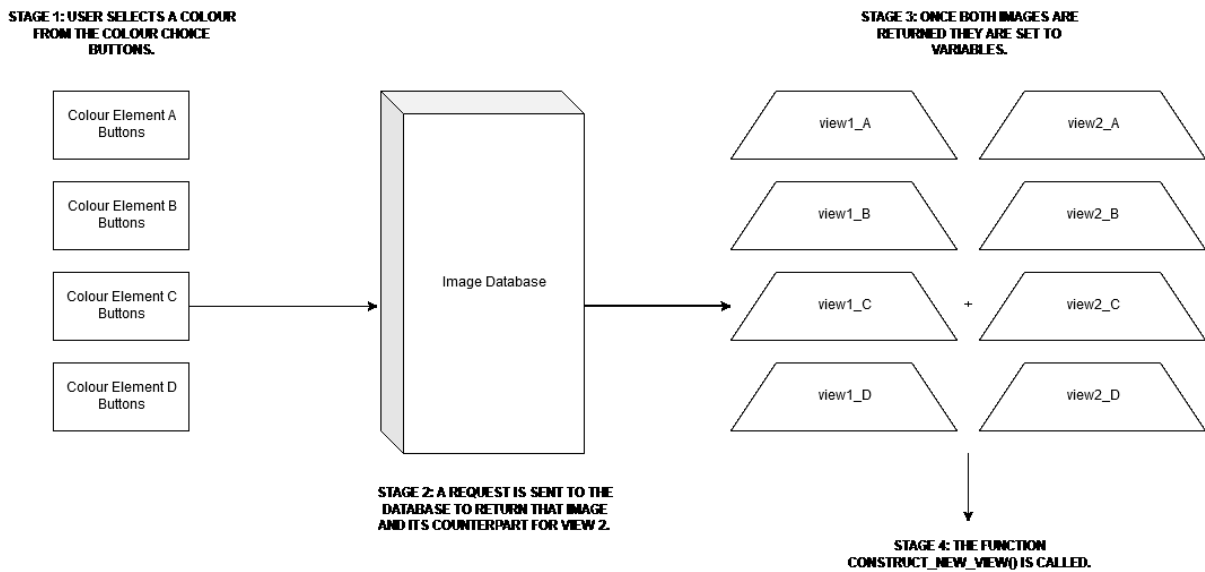


FIGURE 57 - A DIAGRAM DEMONSTRATING THE PROCESS OF IMAGE ACQUISITION

Content and Storage

All data and images used in the product configurator are stored in a database within the Wix platform. The product configurator webpage connects to this database on initialisation so that it can download elements from it at run-time on request. At run-time, the database is set to read-only.

Miscellaneous

```

1 import wixWindow from 'wix-window'
2 import {session} from 'wix-storage'
3 import wixLocation from 'wix-location'

```

FIGURE 58 - THE SCRIPTS IMPORTED IN THE PRODUCT CONFIGURATOR WEBPAGE

The very first thing the webpage does is import several Wix scripts. The wixWindow script tracks events that happen on the webpage so that they can be sent to 3rd party analytic packages. The {session} script provides the ability to save data locally on the browser. The wixLocation script allows the webpage to identify the geographic location the webpage is being used in.

```

83 function bringProductIn() {
84     view1_A = $w("#dynamicDataset").getCurrentItem().view1_a_a
85     view1_B = $w("#dynamicDataset").getCurrentItem().view1_b_a
86     view1_C = $w("#dynamicDataset").getCurrentItem().view1_c_a
87     view1_D = $w("#dynamicDataset").getCurrentItem().view1_d_a
88
89     view2_A = $w("#dynamicDataset").getCurrentItem().view2_a_a
90     view2_B = $w("#dynamicDataset").getCurrentItem().view2_b_a
91     view2_C = $w("#dynamicDataset").getCurrentItem().view2_c_a
92     view2_D = $w("#dynamicDataset").getCurrentItem().view2_d_a
93 }

```

FIGURE 59 - THE FUNCTION BRINGPRODUCTIN()

The “bringProductIn()” function triggers when the webpage initializes. Its purpose is to set the starting view of the product before a user interacts with the webpage. To do this, it downloads images from the database. All starting images are set to the colour white to provide a blank starting point for the user.

```

48     function constructNewView() {
49         Q_productName = $w("#dynamicDataset").getCurrentItem().productName
50         session.setItem("productNameBind", Q_productName)
51
52         Q_productCode = $w("#dynamicDataset").getCurrentItem().code
53         session.setItem("productCodeBind", Q_productCode)
54
55         session.setItem("colourA_Choice", Q_colourA_Choice)
56         session.setItem("colourB_Choice", Q_colourB_Choice)
57         session.setItem("colourC_Choice", Q_colourC_Choice)
58         session.setItem("colourD_Choice", Q_colourD_Choice)
59
60         Q_option1_Name = $w("#dynamicDataset").getCurrentItem().optionOneName
61         session.setItem("option1_Name", Q_option1_Name)
62
63         Q_option2_Name = $w("#dynamicDataset").getCurrentItem().optionTwoName
64         session.setItem("option2_Name", Q_option2_Name)
65
66         Q_option3_Name = $w("#dynamicDataset").getCurrentItem().optionThreeName
67         session.setItem("option3_Name", Q_option3_Name)
68
69         if (currentView === 1) {
70             $w("#layerA").src = view1_A
71             $w("#layerB").src = view1_B
72             $w("#layerC").src = view1_C
73             $w("#layerD").src = view1_D
74         }
75         if (currentView === 2) {
76             $w("#layerA").src = view2_A
77             $w("#layerB").src = view2_B
78             $w("#layerC").src = view2_C
79             $w("#layerD").src = view2_D
80         }
81     }
82

```

FIGURE 60 - THE CONSTRUCTNEWVIEW() FUNCTION USED IN THE PRODUCT CONFIGURATOR WEBPAGE

The function constructNewView() is responsible for the active content displayed in the product visualizers image group. When called, depending on the current view selected, it overwrites the active image group content with the content parameterized to the variables declared in Figure 55.

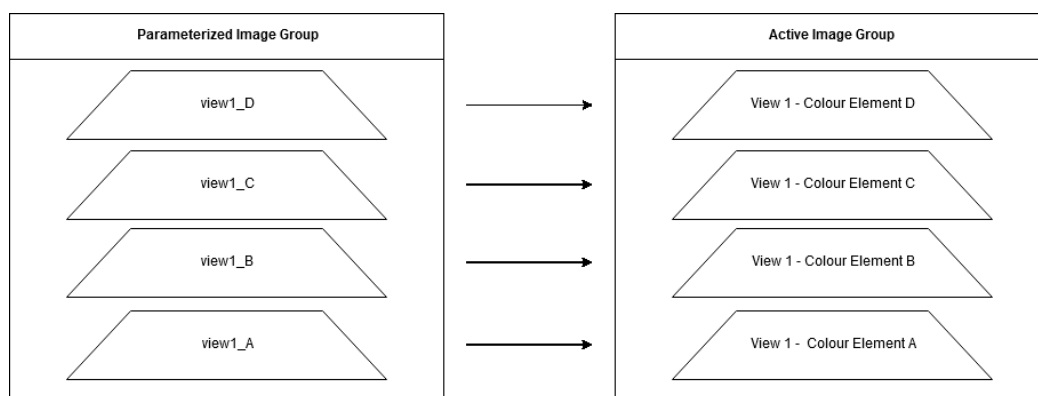


FIGURE 61 - A DIAGRAM DEMONSTRATING THE STRUCTURE OF THE CONSTRUCTNEWVIEW() FUNCTION

6. RESULTS

This project aimed to see how much benefit there was to using game technology in place of traditional rendering methods involved in creating a product configurator. As outlined in Chapter 2.1 the aspects of development that this project attempted to streamline where;

Programming Back End

In the original proposal, the estimated time required to complete the back-end programming of the database and application structure was estimated to be 30 days. While this specific task did not happen, its counterpart - the game engine rendering solution discussed in Chapter 5 took 43 days to program.

Rendering Images

One year was set aside in the original proposal for rendering product images, and it was specified that there would be an image rendered for every single colour combination, leading to a total of 282,320 images being needed. Due to this project developing the product configurator differently, it only needed to produce 4840 images. The total time required to render these images was 310 seconds. The rendering algorithm outlined in Chapter 5.14 renders 15 images per second.

Hypothetically if this project was to render 282,320 images, it could do so in 301 minutes.

Configurator Development

In the original proposal, 90 days were set aside to develop the iOS product configurator application. In total, this project spent 39 days developing the REM product configurator.

Image Administration

Thirty days was initially set aside for administering images. This project completely removed the need for any image administration to take place; all images produced were automatically earmarked and stored in an organised directory.

Database Data Entry

In the original proposal, the estimated time required to upload all the images into a database was 90 days. This project spent 71 days manually uploading all the product images to the Wix database.

Task	Proposal Time (Days)	Project Time (Days)
Programming Back End	30	43
Rendering Product Images	360	<1
Configurator Development	90	39
Image Administration	30	0
Database Data Entry	90	71

While this project did take more time to develop the back-end solution than the proposed counterpart, in total, this project saved 452 days of development time over. The bulk of this gain comes from the increased rendering production.

As previously discussed, REM had a set of requirements for the project that needed to be met. They were;

- Updating the product configurator with annual changes can take no longer than two-months.
- Once developed, it must be available for REM's wholesalers to use across the country.
- It must feature every product in every single colour combination.
- One person must develop it.
- It must be available to use on PC, tablet and mobile.
- It must be ready for release by July 2019.

Given the speed at which the rendering algorithm produces images, rendering a full set of product images can happen well within the two-month development window that REM dictated. The only other requirement that needs to be factored in is the 3D modelling of new products being added to the REM collection in the annual update. A large part of the viability involved in the two-month update window depends on the amount of changes REM decides to make to its catalogue. Technically, this project can easily update the assets used in the REM product configurator well within the two-month update window.

The project is easily available for REM's wholesalers to use. Any person with an internet connection and device that features mobile browsing can use the REM product configurator. It is already available on PC's, tablets and mobiles. The solution does not feature every product, due to time constraints, some products were unable to be developed, but every product that is featured comes with its full-colour combinations available. The project was indeed developed by a single person and was released on the 1st of April 2019.

Since release, the product configurator has improved sales for several of REM's wholesalers, with one, in particular, seeing large increases in sales. In the first 6-months post-release, it has been identified that on the websites where the REM product configurator has been implemented, there has been a fourfold increase in customer traffic. The growth of the solution as of December 2019 is going well, since release, every month, it has grown by over 20%, month on month. At the beginning of the release, this growth was in part due to an increase in the number of websites that it had been implemented on. However, this specific growth stopped in September 2019, and even still, the platform is growing.

The implementation of the product configurator project with REM's current business model has been seamless. Due to the simplicity of the solutions webpage implementation, developers need only add a single line of code to a webpage to instantiate it on their websites. The ease of implementation has meant that it has been adopted by many of REM's wholesalers that use the internet for their sales. As of December 2019, the product configurator is now also being used in showrooms across the UK, predominantly on tablet devices. Customers who are browsing REM products have also started to bring with them print-outs of products they have assembled using the product configurator to stores and showrooms across the UK. Its adoption has been a massive benefit to REM as the need to train sales staff on the complexities of REM products is now far more diminished. The accessibility of REM products for customers and wholesalers alike has been increased to the point where annual training seminars conducted by REM at great expense may no longer be needed, and the physical material books that are sent to customers for them to view are also possibly obsolete. A selection of website address for several REM product configurator examples is in Appendix 1.

REM Satisfaction Post Launch

Once the REM product configurator became available in April 2019, REM sent out an internal questionnaire to its office staff to complete anonymously, there were 23 questionnaires submitted. This was an informal collection of opinion and sentiment in the company's staff, it provides an insight into the perceived success of the project at large with the audience that would be the most educated on the industry, company and customer base. The questionnaire included several multiple-choice questions and the results were as follows;

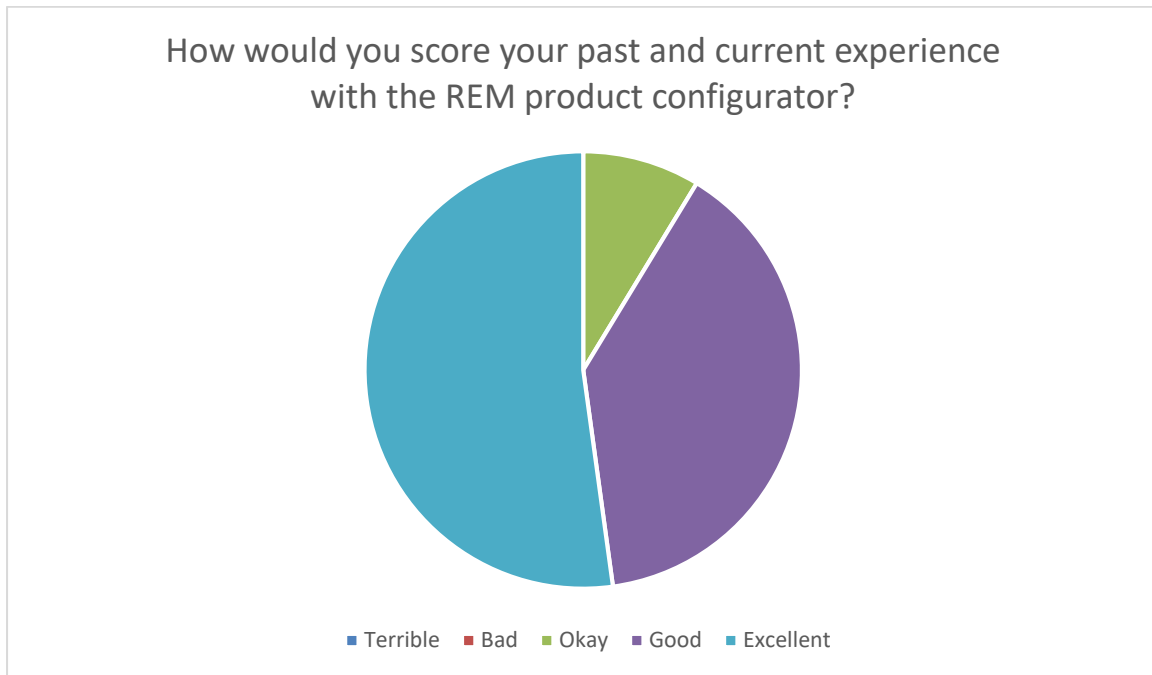


FIGURE 62 – A GRAPH TO DEMONSTRATE THE VIEWS HELD BY REM'S STAFF ON THE REM PRODUCT CONFIGURATOR

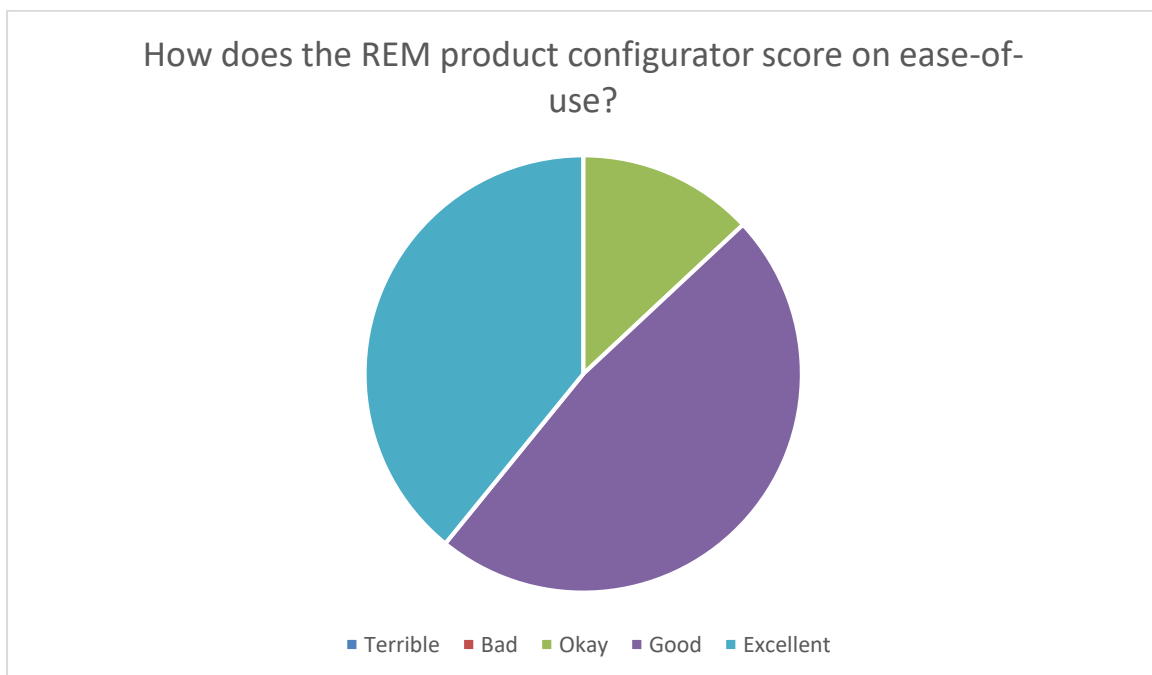


FIGURE 63 – A GRAPH TO DEMONSTRATE THE VIEWS HELD BY REM'S STAFF IN REGARDS TO EASE-OF-USE

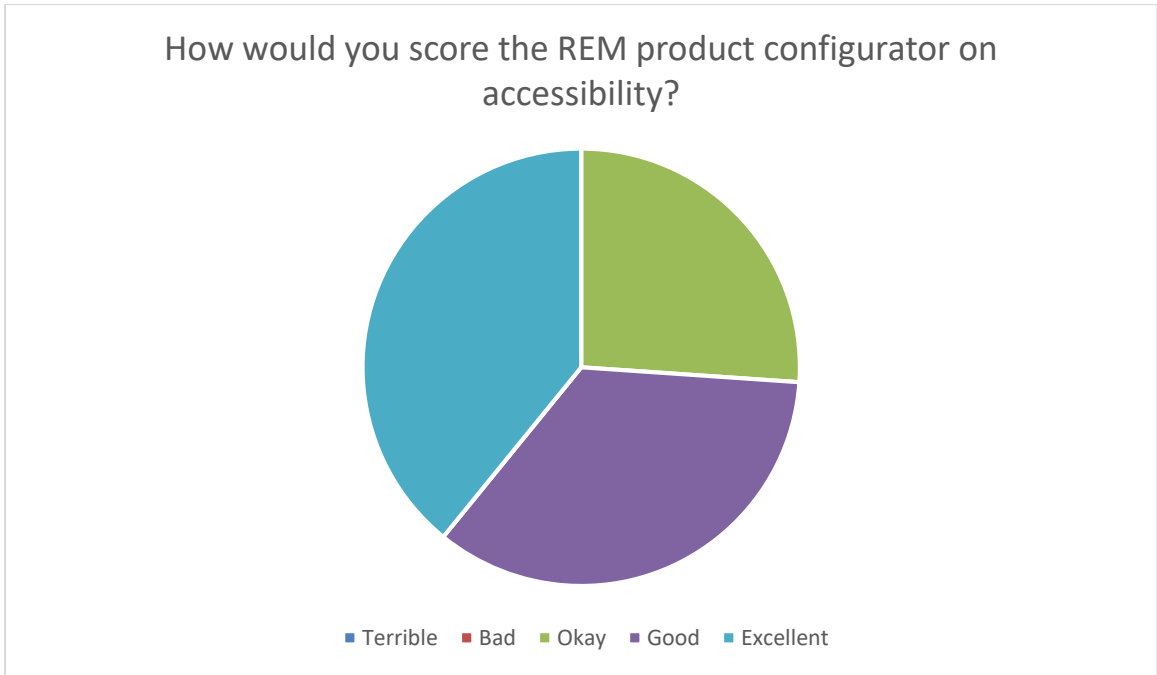


FIGURE 64 – A GRAPH TO DEMONSTRATE THE VIEWS HELD BY REM’S STAFF IN REGARDS TO ACCESSIBILITY

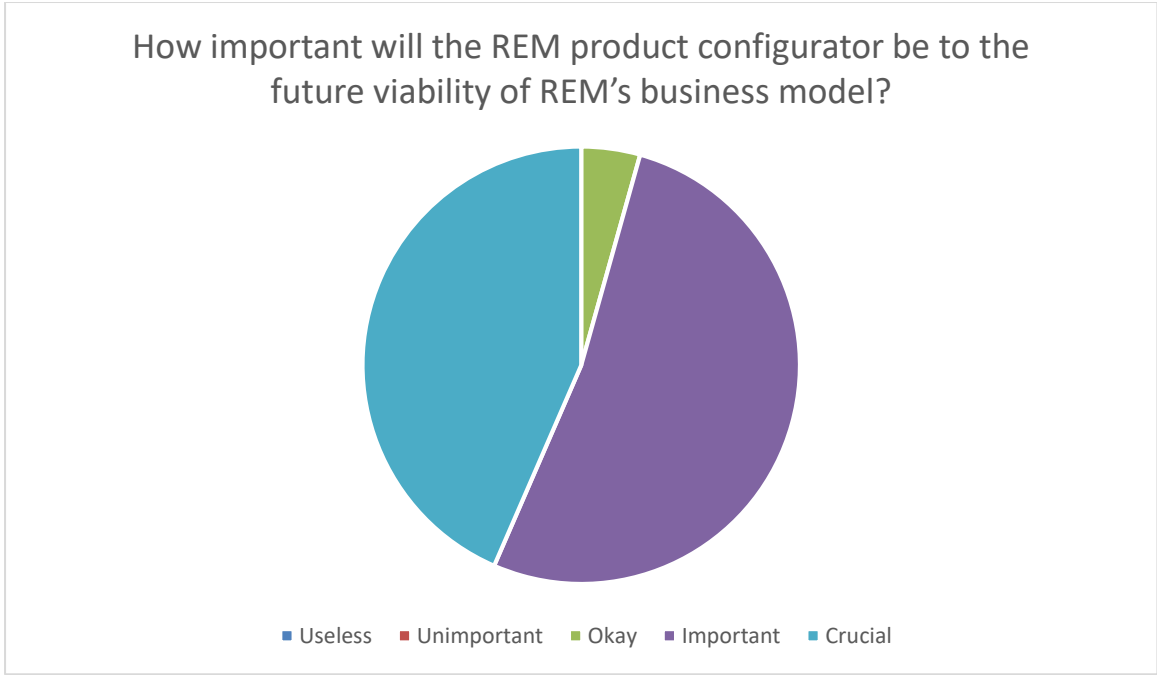


FIGURE 65 – A GRAPH TO DEMONSTRATE THE VIEWS HELD BY REM’S STAFF IN REGARDS TO THE OVERALL CONTRIBUTION OF THE REM PRODUCT CONFIGURATOR TO REM’S BUSINESS FUTURE

The overall sentiment held by REM staff was positive, most staff members felt that the project was an important addition to the company’s commercial ventures. Based on the results of the questionnaire it became apparent that the project was being used in different ways than was intended, these unforeseen positive outcomes have caused REM to review potential blind spots in its commercial strategy at large. The majority of project use was focused on showing customers products in different colour combinations as intended. All the questionnaires submitted in this study can be found in Appendix 2

REM Performance Post Launch

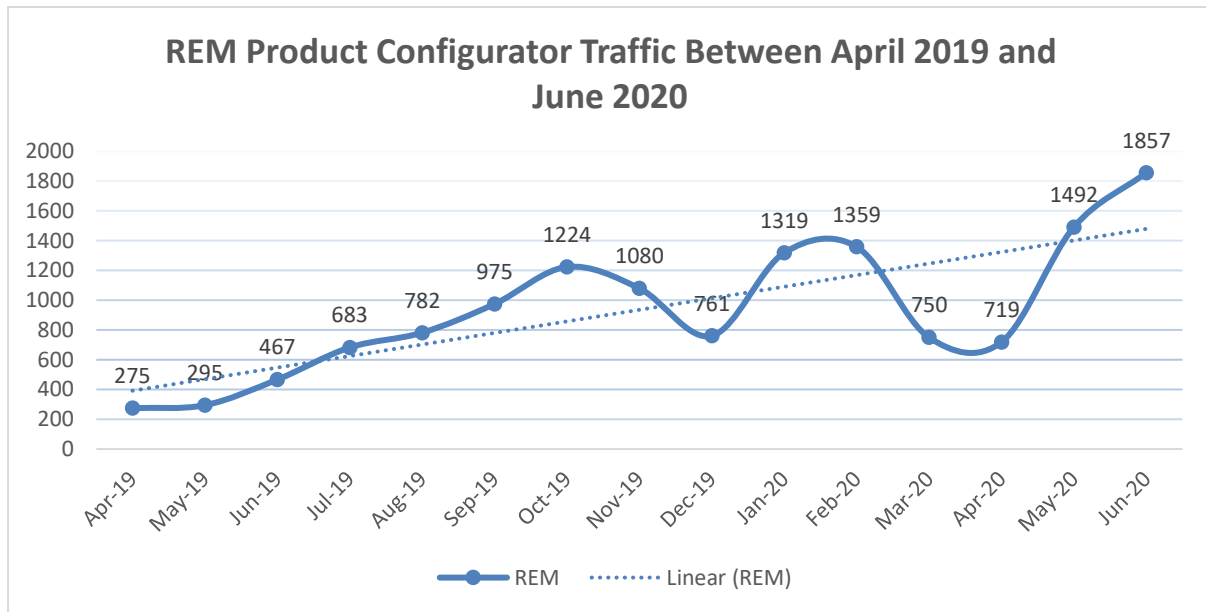


FIGURE 66 - THE DIFFERENCE IN REM'S CONFIGURATOR TRAFFIC OVER TIME

As the graph above demonstrates the traffic coming into the REM product configurator has shown somewhat steady month on month growth, with the only two exceptions being the expected industry downturn of the Christmas period and the recent coronavirus lockdown. As of June 2020, the project is being used by 6.75 times more people than when launched originally. Which means, there has been a multiplicative increase in the number of people who visit and use the product pages of REM's wholesaler websites who have implemented the REM product configurator. The increase in traffic led to the REM website being placed two ranks higher on google's search results, which in turn has helped the company's main website grow its traffic organically for the first time since 2011. The graph below demonstrates this growth since the release of the project.

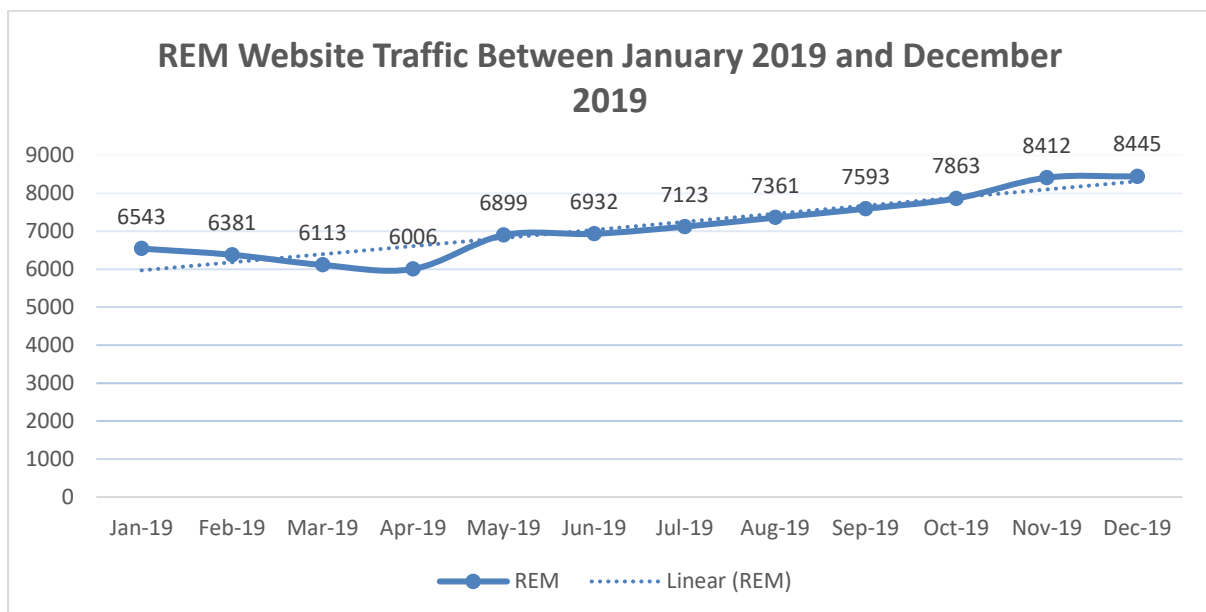


FIGURE 67 – REM'S WEBSITE GROWTH IN 2019

Wholesaler Satisfaction Post Launch

6-months after the launch of the project REM reached out to its top ten wholesalers and asked them to fill out a questionnaire in regard to their thoughts on how successful the project had been so far. For the purposes of confidentiality, the names of the companies have been removed and replaced with an index. Like the previous questionnaire this was done internally and informally by REM – but the data does provide insight into how these companies viewed the performance of the project. The results were as follows;

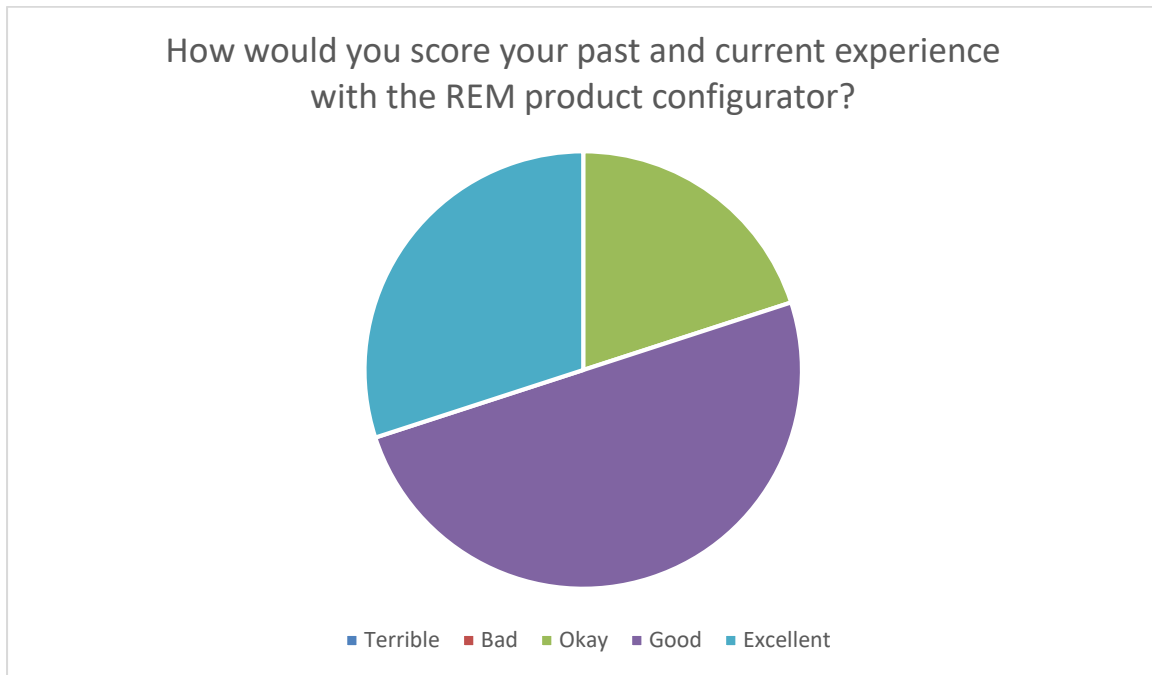


FIGURE 68 - THE VIEWS HELD BY REM'S WHOLESALERS ON THE REM PRODUCT CONFIGURATOR

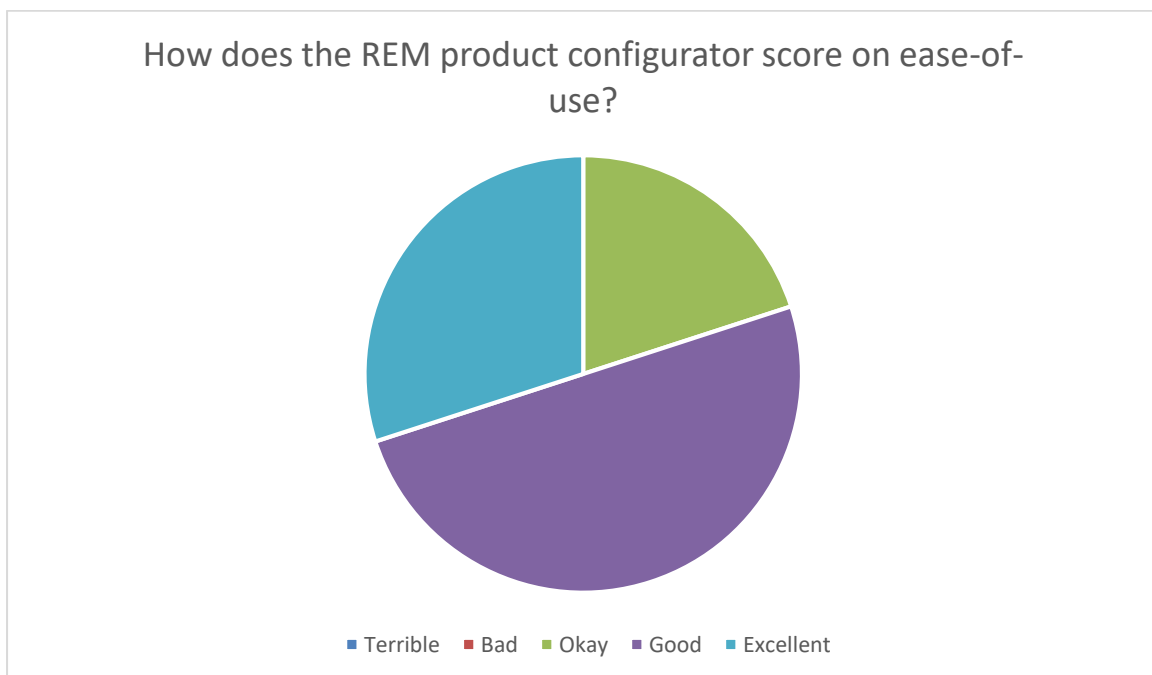
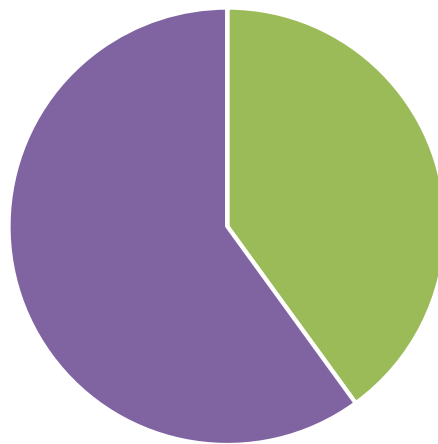


FIGURE 69 - THE VIEWS HELD BY REM'S WHOLESALERS IN REGARDS TO EASE-OF-USE

How would you score the REM product configurator on accessibility?



■ Terrible ■ Bad ■ Okay ■ Good ■ Excellent

FIGURE 70 - THE VIEWS HELD BY REM'S WHOLEASLERS IN REGARDS TO ACCESSIBILITY

How important will the REM product configurator be to your future sales of REM products?



■ Useless ■ Unimportant ■ Okay ■ Important ■ Crucial

FIGURE 71 - THE VIEWS HELD BY REM'S WHOLEASLERS IN REGARDS TO THE FUTURE SALE OF PRODUCTS

The sentiment held by REM's wholesalers towards the outcomes of the project was largely positive. The fact that most wholesalers thought that the project would help them sell more REM products in the future was seen as a crucial victory for the project overall, since at the start of the project one of the biggest hurdles identified would be the quandary of convincing wholesalers to try new sales techniques that involved digital solutions. Several wholesalers that typically sold other brands of products started to sell increased amounts of REM products in response to the projects release – which again was an unforeseen outcome - as its wasn't expected that these actors would embrace such a solution. All the questionnaires submitted in this study can be found in Appendix 3.

Wholesaler Performance Post Launch

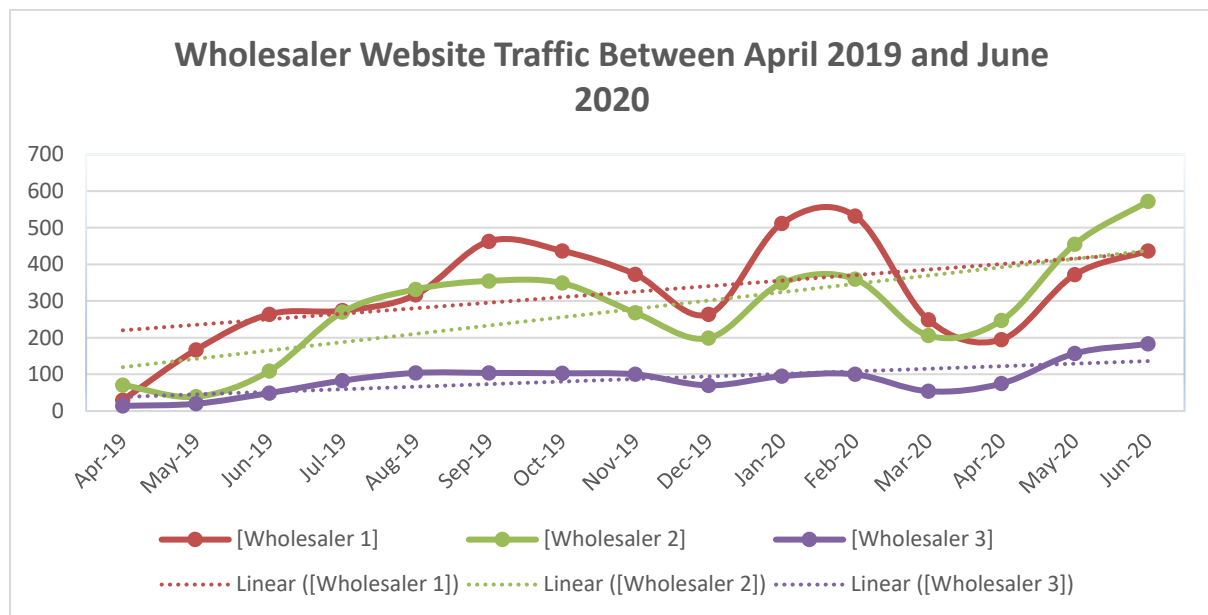


FIGURE 72 - THE TRENDS IN WHOLESALER WEBSITE TRAFFIC OVER TIME

Unfortunately, data from all of REM’s wholesalers could not be included due to confidentiality terms. But three wholesalers were fine with their data being studied so long as the names of the companies were redacted. As you can see from the above graph, much like the REM website traffic graph there has been a steady increase in the amount of visitor’s overtime with the aforementioned downturns considered. For the first time in a little under a decade has led to measurable growth in the amount of commercial interest in REM and its products.

While this study cannot reveal particular revenue values for any company related to this project. It can be said that the project has had a positive impact on the commercial outcomes of most companies that have implemented and actively used it. Interestingly, while all of REM’s top ten wholesalers did implement it in some way, the companies that used it on their websites and showrooms saw the largest increases in customer quotes and visitors. The wholesaler that found the most use for the project was an online only wholesaler that took orders directly online. This company only had several staff members, no showrooms and no travelling sales team but had a professional website. They included the project as part of the ordering process for customers and have found substantial success in doing so.

This would hint at an audience difference between REM’s wholesalers, previously it was thought that a customer would float between different wholesalers looking for the best price. But based on the findings of this project it would now be apt to speculate that each wholesaler has a different type of customer that they attract, and that the REM product configurator has weighted outcomes based on the type of customer that interacts with it. Simply put, there seems to be indications that customers who are more experienced and relaxed with web technology and online sales use the project more than customers who prefer the usual way of ordering products, which would be done in a showroom with a sales representative. This is not to say that the project doesn’t help in these environments, but it seems to help more in the explicitly online sphere rather than the real world. But more analysis needs to be conducted on this topic to reach a solid conclusion.

7. DISCUSSION

The critical findings found during this research project are;

- Game technology can successfully be implemented to help develop certain aspects of product configurator production.
- The inclusion of game technology in these projects can result in a massive increase in the productivity of certain developmental tasks.
- The task types that game technology can assist with the most include rendering, content management and data entry.
- The creation of a 2D product configurator application is more viable than initially considered, providing that a solution like the one demonstrated in this research is used in production.

In line with the hypothesis outlined in Chapter 3, game technology can be applied to certain development tasks involved in creating a product configurator. Game technology cannot be applied to all aspects of developing this type of application, but in the areas where it can, it will provide massive increases in development speed, making tasks that previously took up the majority of development time, now take up the least. It was somewhat expected that applying game technology would provide some level of increased productivity; any form of automation does typically do this; what is unexpected is the level of improvement it made. Even more, the solution shown in this research is scalable, meaning that it will provide even more considerable benefits to projects that require even more rendering. In Chapter 2.3 one of the product configurators reviewed was the Xbox Design Lab, a product configurator with vast amounts of variable scope, it was observed that it was not entirely clear how the resources used in the product visualiser were created on such a scale. At this stage, it would be apt to say at the very least, that the Xbox Design Lab could use a solution like the one developed in this research.

The speed increase demonstrated when rendering product images is massive. Instead of it taking 360 days to render, as proposed in REM's original product configurator development overview, the same task, albeit with a slightly different methodology, produces the same desired outcomes in a fraction of the time. However, this is not the only improvement made to the viability of development, the necessity to hire two new employees to work full time on rendering product images is removed, and the organisational element of sorting and storing these images is automatically completed. REM's original request of having a single person develop the project has now become viable, and the requirement that the two-month annual update cycle is maintained has also been successful.

There is no reason why this solution is limited to only applying to REM products. As covered in Chapter 2.2, the product configuration field features many different types of products, ranging from simple shapes like a desk up to complex photorealistic car models. From a technical standpoint, the fundamentals of this solution are not dependant on the type of product featured, and so there is no reason why this solution could not be used or featured as part of the development for another product configurator even if it is to assist in the singular task of rendering product images.

The implications of this project are interesting; product configurators are a niche section of commercial product marketing. Some companies choose to develop product configurators, and others choose not to, but all commercial businesses must produce marketing materials for their products. With several simple changes, this project could be used for producing vast amounts of product imagery. This imagery could be used in any commercial channel that features images, such as social media platforms, leaflets,

catalogues, newsletters, websites, product pages, user manuals and more. Feasibility, the rendering algorithms production capabilities could supplant the need for traditional rendering solutions in every circumstance where product renders are required. Given the capabilities of game engines, it would be possible even to render video or animations of products very easily.

The solution does come with limitations, for it to work elsewhere, a future developer would have to use the same data structure as outlined in Chapter 5. Also, 3D models would have to be developed using the specification outlined in Chapter 5.3 So, there are costs for using a solution like this, but the costs of these conformities are but a fraction of the total cost it would take to use traditional rendering software to complete the same task. The solution demonstrated in this research has achieved good results, but some extra work could be conducted on increasing its performance, even more, these changes include;

Automatic Alpha Deletion

One of the biggest tasks that result from rendering images like this is that the alpha channel of a screenshot remains intact, and so it must be manually deleted by someone before it can be added to the configurator database. Unreal Engine 4 can already automatically delete alpha channels of screenshots but can only do so with a screenshot taken from the editor and not from the run-time version of the application. The developers of Unreal Engine 4 addressed the issue, and it is now in the process of being rectified. Once rectified, the inclusion of several additional lines of code in the custom C++ blueprint function created in Chapter 5.13 will result with the solution being able to cull all white pixels from a screenshot taken at run-time before it is committed to memory. Thereby creating an image with a transparent background.

Automatic Compression

Image compression is the second manual task that's needed to be completed once a product image has been rendered. This task is not technically necessary, as it does not change the viability of the solution. However, its inclusion does improve the end-user experience of the product configurator by making images download faster. Smaller sized images will make the product configurator seem more responsive and use less data for mobile users. Unreal Engine 4's native file format for images is TGA, which traditionally is one of the larger file formats for images as it supports 32-bit colour. An improvement could be made where this default file format could be changed to 8-bit PNG which would provide moderate reductions in image memory size while maintaining the same resolution.

Automatic Uploading (No Database Needed)

Automatic uploading would be a more experimental feature, but the inclusion of a database with the product configurator is the projects most cumbersome element. Ideally, it would be better if there was no database at all. The solution to this is quite simple. In the product configurator source code, its currently programmed to download images from its Wix database. Instead, it could be programmed so that it would pull images from a static IP address. Having a static IP would slow download speeds slightly as the Wix database is a secure connection, and a static IP would not be. Nevertheless, the labour reduction in manually uploading images to the database, which is quite a time-consuming task, would be eliminated.

Increase in Resolution

Currently the product configurator uses 1920x1080px images presented in a content widget that's 960x540px in size. This resolution results in some good image sampling and sharpening but creates a problem with the anti-aliasing on the edges of the image. The image quality can be advanced by increasing the resolution of the images used. The way to do this is straightforward, Unreal Engine 4's "FULLSCREEN" console command uses the resolution of the active monitor. This project used a 1920x1080px monitor, and therefore the images reflect this resolution. If the project were displayed on a 3820x2160px monitor, the resolution of images captured by the rendering algorithm would quadruple – meaning that the anti-aliasing effect would be much less noticeable. Higher resolutions would increase the memory size of each image, so due diligence is required in its implementation, but this inclusion could be mitigated by including these higher resolution images in a "high quality" mode feature on the product configurator.

Better GPU Profiling

Unfortunately, there was no time in this project to include the GPU profiling feature in Unreal Engine 4. There are many further improvements to rendering performance that could be made by utilising the GPU profiler. Firstly, the draw call count of each product could potentially be lowered, as stated in Chapter 5.3 model groups were created for each colour element but were not created for all the miscellaneous objects on a product like its buttons, lights, handles, feet and logo. There is no reason why these meshes could not be grouped into a single mesh with several UV channels. This consolidation would reduce the number of draw calls required to draw the scene and therefore would increase the rendering threads performance, how much by is unclear, this would need to be determined through investigation.

Digital Material Improvements

As discussed in Chapter 5.5, the resolution of photography captures used 3000x3000px. These captures could be reduced to a lower resolution provided that the end-users did not notice the decrease in visual quality. However, since the product renders are natively at 1920x1080px and then downsampled to 960x540px, there is good reason to suspect that lowering the resolution of the photography captures would not be noticeable by the end-user. By reducing the resolution, there would be a marked decrease in the texture cache required to run the rendering algorithm. Alternatively, if the goal was to reduce the texture cache required to run the rendering algorithm, and it could not come at the cost of any assets resolution being decreased, normal maps could be removed from the materials, their effect on the product renders has turned out to be negligible at best. It is very likely that if normal maps were removed, end-users would not be able to notice any difference in visual outcomes.

Raytracing

During the timeline of this project, certain technological innovations happened that could not be included. One of these innovations is NVIDIA's RTX raytracing feature. RTX raytracing is already available in Unreal Engine 4, but only when using series 2060 RTX GPU's or above. This project used an NVIDIA GTX 1080 Ti and so, this feature was not available. If the GPU was updated to a more recent model, raytracing could be used to calculate all the lighting, reflections and shadows in the product levels. Raytracing would likely add to the rendering cost of the scene overall but would increase the rendering

quality abundantly. The biggest benefactors of this inclusion would be elements such as reflections and ambient occlusion, much extra work had to be conducted on these aspects due to several products, and this added to the overall development time of the project. If raytracing were used, work would not have to be conducted on these aspects of development. Additionally, real-time raytracing would eliminate the need to bake static lighting in levels before rendering, saving an abundant amount of development time overall.

Front-end Content Management

One of the most significant improvements that could be made to the project is the inclusion of a front-end content management system, including this, would mean someone with no experience in using Unreal Engine 4 could update and edit the capabilities and content used by the rendering algorithm. All that would be required would be a user interface that would expose certain variables to the user for modification. These variables would be;

- String value and texture value of a material structure
- The ability to add or remove materials in the material arrays
- The ability to create a new product level or delete obsolete ones
- The ability to create a new product instance or delete an obsolete one

The way this could be included is using the UMG blueprint system, UMG blueprints are like actor blueprints with the only difference being that a UMG blueprint is a 2D scene element rather than a 3D scene element. This inclusion would likely take large amounts of development time, but if added successfully, would make updating the rendering algorithm much easier.

This project has touched on the theme that there are differences between 2D and 3D product configurators that are more than technical deviations. However, it would be helpful to identify whether or not choosing a 3D product configurator over a 2D version creates any differences in outcomes from a commercial perspective. The entire reason product configurator development exists is to create solutions that benefit the sale of certain products. However, it is not yet apparent which type of product configurator customers prefer. The tacit assumption seems to be that because 3D product configurators are more challenging to create from a technical standpoint, they must produce enhanced outcomes over their 2D counterparts. A starting point to establishing this research would be to create both types of product configurator for the same products. Once development was complete, it would release the 2D version to the consumer base and collect data on performance. After a set period, the 2D version would be replaced by its 3D counterpart, and then an analysis would be run to identify whether or not there are any differences in commercial outcomes.

In conclusion, game technology can be used to assist in the development of product configurators. Its inclusion brings with it a plethora of advantages that traditional development methods lack. However, utilising game technology like this does not outright remove the risk associated with developing a product configurator; it can only help reduce it. Product configurator projects are massive undertakings that are not to be taken lightly. REM successfully released its product configurator within the set release window, and this tool has created many positive commercial outcomes for the business. The development of the solution created in this project will now be continued by REM as the company looks to the future.

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,90T6CGN08P38:3L99,90K4\$GTL\$KML:LZXC,9102F5Z9J68L:HS8S,936X3M90WS2S:6NSF,90SX28477R3L:BN9B [Accessed 28 Jul. 2018].

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9. APPENDICES

9.1. APPENDIX 1

Product	Configurator Web Address
Saturn Desk 3x3	https://www.remuksalons.co.uk/rem-configurator/saturn-desk-3x3
Glow Island	https://www.remuksalons.co.uk/rem-configurator/glow-island
Magnum Chair	https://www.remuksalons.co.uk/rem-configurator/magnum-chair
Centenary Wall	https://www.remuksalons.co.uk/rem-configurator/centenary-wall
Montana Unit	https://www.remuksalons.co.uk/rem-configurator/montana-unit

9.2. APPENDIX 2

#	Questionnaire Image																																								
#1	<div style="text-align: center;"> <h1>REM</h1> <p>REM Anonymous Employee Configurator Questionnaire - 15/07/2019</p> <p>What is your department of work?</p> <div style="border: 1px solid black; padding: 2px; width: 80%; margin: 0 auto;">Sales</div> <p>What is the most important task you need to perform when using the REM product configurator?</p> <div style="border: 1px solid black; padding: 2px; width: 80%; margin: 0 auto;">Show customers the different colour combinations on products</div> <p>How would you score your past and current experience with the REM product configurator?</p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> </tr> </tbody> </table> <p>What device do you typically use when using the REM product configurator?</p> <div style="border: 1px solid black; padding: 2px; width: 80%; margin: 0 auto;">Mobile</div> <p>How does the REM product configurator score on ease-of-use?</p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td>X</td> <td></td> </tr> </tbody> </table> <p>How would you score the REM product configurator on accessibility? <i>(How easy it is to find and use)</i></p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td>X</td> <td></td> <td></td> </tr> </tbody> </table> <p>How important will the REM product configurator be to the future viability of REM's business model? <i>(Will it help us grow as a business or not)</i></p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Useless</th> <th>Unimportant</th> <th>Okay</th> <th>Important</th> <th>Crucial</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> <td>X</td> </tr> </tbody> </table> <p>What haven't we asked you today that you think would be valuable for us to know?</p> <div style="border: 1px solid black; padding: 2px; width: 80%; margin: 0 auto;">Would be great if all the remaining products could be added ASAP</div> </div>	Terrible	Bad	Okay	Good	Excellent				X		Terrible	Bad	Okay	Good	Excellent				X		Terrible	Bad	Okay	Good	Excellent			X			Useless	Unimportant	Okay	Important	Crucial					X
Terrible	Bad	Okay	Good	Excellent																																					
			X																																						
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			X																																						
Terrible	Bad	Okay	Good	Excellent																																					
		X																																							
Useless	Unimportant	Okay	Important	Crucial																																					
				X																																					

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Customer Service

What is the most important task you need to perform when using the REM product configurator?

Sending quotes out to customers

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

PC

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				x

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				x

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

Well done Niall :D

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

sales

What is the most important task you need to perform when using the REM product configurator?

Explaining colour combinations to customers in home visits

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
		x		

What device do you typically use when using the REM product configurator?

Phone

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
		x		

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		x		

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

Runs a little slow on my phone but it all works so far

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Marketing

What is the most important task you need to perform when using the REM product configurator?

Creating social media posts

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

What device do you typically use when using the REM product configurator?

Desktop

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

This is a really good starting point.

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Sales

What is the most important task you need to perform when using the REM product configurator?

Use it like a catalogue but don't need to carry any catalogues around with me anymore

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Order Processing

What is the most important task you need to perform when using the REM product configurator?

Sending images to customers of products

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		x		

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

A very useful tool, good job Niall!

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Order Processing

What is the most important task you need to perform when using the REM product configurator?

Sending quotes to customers

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			o	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			o	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		o		

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			o	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Order processing

What is the most important task you need to perform when using the REM product configurator?

Showing products to customers who enquire about what products look like in different colours

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				o

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				o

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				o

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				o

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Marketing

What is the most important task you need to perform when using the REM product configurator?

Creating images for social media

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Customer Service

What is the most important task you need to perform when using the REM product configurator?

Sending customers a picture of the product they bought on the delivery reminder

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				<input type="radio"/>

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				<input type="radio"/>

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				<input type="radio"/>

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				<input type="radio"/>

What haven't we asked you today that you think would be valuable for us to know?

Why didn't we have this 10 years ago???

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Manufacturing

What is the most important task you need to perform when using the REM product configurator?

Showing customers products in different colours when doing bespoke consultation

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

Top tool

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

What is the most important task you need to perform when using the REM product configurator?

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
		x		

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		x		

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Customer Service

What is the most important task you need to perform when using the REM product configurator?

Learning about products myself

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

Well done Niall

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Manufacturing

What is the most important task you need to perform when using the REM product configurator?

Don't need it for work really but good to look at

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

Phone

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				x

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				z

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

Really good

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Manufacturing

What is the most important task you need to perform when using the REM product configurator?

Helps me put together slideshows for internal meetings about products

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				o

What device do you typically use when using the REM product configurator?

Desktop PC

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				o

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				o

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				o

What haven't we asked you today that you think would be valuable for us to know?

Wash points still need adding!

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Manufacturing

What is the most important task you need to perform when using the REM product configurator?

Helps me explain products to customers when doing bespoke

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Manufacturing

What is the most important task you need to perform when using the REM product configurator?

Good to see all the products in different colours

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
		x		

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
		x		

What haven't we asked you today that you think would be valuable for us to know?

Be good to see all the products added

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Showroom

What is the most important task you need to perform when using the REM product configurator?

Showing products off in different colours to customers

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				x

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				x

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

Cant believe Niall managed it TBH, well done!

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Showroom

What is the most important task you need to perform when using the REM product configurator?

Use it with customers in showroom on my iPad

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				o

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				o

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				o

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			o	

What haven't we asked you today that you think would be valuable for us to know?

Perfect for when I go make the visitors a brew, I give them my iPad and they play around with it

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Product Development

What is the most important task you need to perform when using the REM product configurator?

The analytic reports that Niall produces from it (most popular combinations etc)

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				X

What device do you typically use when using the REM product configurator?

Desktop PC

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				X

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				X

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			X	

What haven't we asked you today that you think would be valuable for us to know?

Think the mobile versions needs a little work

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Sales

What is the most important task you need to perform when using the REM product configurator?

Invaluable for training sessions with wholesaler sales staff

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				x

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
				x

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

This has made life so much easier for all of Sales! And [its](#) just the starting point!

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Purchasing

What is the most important task you need to perform when using the REM product configurator?

Learning about the products

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			o	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
		o		

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		o		

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			o	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Anonymous Employee Configurator Questionnaire - 15/07/2019

What is your department of work?

Purchasing

What is the most important task you need to perform when using the REM product configurator?

Putting the 2nd hand products on Ebay (images etc)

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			X	

What device do you typically use when using the REM product configurator?

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			X	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			X	

How important will the REM product configurator be to the future viability of REM's business model? *(Will it help us grow as a business or not)*

Useless	Unimportant	Okay	Important	Crucial
			X	

What haven't we asked you today that you think would be valuable for us to know?

9.3. APPENDIX 3

#	Questionnaire Image																																								
#1	<div style="text-align: center;"> <h1>REM</h1> <p>REM Wholesaler Questionnaire - 15/10/2019</p> <p>Are you using the REM product configurator, and if so how?</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Yes, we use it on our website</div> <p>What is the most important task you need to perform when using the REM product configurator?</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Allows our customers to play around with product combinations on our website</div> <p>How would you score your past and current experience with the REM product configurator?</p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> <td>o</td> </tr> </tbody> </table> <p>How does the REM product configurator score on ease-of-use?</p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> <td>o</td> </tr> </tbody> </table> <p>How would you score the REM product configurator on accessibility? <i>(How easy it is to find and use)</i></p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Terrible</th> <th>Bad</th> <th>Okay</th> <th>Good</th> <th>Excellent</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td>o</td> <td></td> </tr> </tbody> </table> <p>How important will the REM product configurator be to your future sales of REM products?</p> <table border="1" style="margin: 0 auto; text-align: center;"> <thead> <tr> <th>Useless</th> <th>Unimportant</th> <th>Okay</th> <th>Important</th> <th>Crucial</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td>o</td> <td></td> </tr> </tbody> </table> <p>What haven't we asked you today that you think would be valuable for us to know?</p> <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: 80%;"> <p>Very good starting point, in the future it would be good to see an expansion of the products that are available on it, wash points especially. Customer feedback has been really positive so far. Most customers don't expect that a tool like this would be available and so are pleasantly surprised that they can play around with products from their homes now without needing to visit one of our showrooms. We think that a large part of the recent improvement in sales is due to the increase in website sales which is almost certainly due to the inclusion of the configurator.</p> </div> </div>	Terrible	Bad	Okay	Good	Excellent					o	Terrible	Bad	Okay	Good	Excellent					o	Terrible	Bad	Okay	Good	Excellent				o		Useless	Unimportant	Okay	Important	Crucial				o	
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Useless	Unimportant	Okay	Important	Crucial																																					
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REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

We use it in our showrooms

What is the most important task you need to perform when using the REM product configurator?

Showing customers different products in different colours

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			x	

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			x	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		x		

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
		x		

What haven't we asked you today that you think would be valuable for us to know?

A helpful tool in showrooms, would be great if we could send some sales staff over to have their training updated with this.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

Yes, we use it with home visits mainly.

What is the most important task you need to perform when using the REM product configurator?

Showing customers different colour combinations.

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				x

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				x

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
				x

What haven't we asked you today that you think would be valuable for us to know?

Firstly, great job on this project I know it's taken a long time to make. Secondly its really helpful that the colour code system you guys use is now not needed when explaining colours to customers. It saves a lot of time when doing home visits and likely saves a lot of order errors coming into out branches. We are going to try and use it in our showrooms in the future.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

We use it on our website product pages.

What is the most important task you need to perform when using the REM product configurator?

Just having that tool there available for use is a massive advantage when selling REM.

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			X	

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			X	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		X		

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
			X	

What haven't we asked you today that you think would be valuable for us to know?

Makes REM must easier to sell over other brands, we have seen an increase in the number of quotes were getting from customers since the release of it.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

Showrooms, home visits

What is the most important task you need to perform when using the REM product configurator?

Sending it to customers before out sales reps get there

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			o	

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			o	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			o	

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
		o		

What haven't we asked you today that you think would be valuable for us to know?

It's good but It would be way better if it was fully 3D and on iPads. Ikea have an app that lets you project that furniture into your room, would be ace if your configurator department could make that for REM.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

We use it in our customer service department

What is the most important task you need to perform when using the REM product configurator?

Sending customers quotes

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
		x		

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
		x		

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			x	

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
			x	

What haven't we asked you today that you think would be valuable for us to know?

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

We use it on our website currently

What is the most important task you need to perform when using the REM product configurator?

Shows customers different products in different colours

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
				o

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			o	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			o	

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
				o

What haven't we asked you today that you think would be valuable for us to know?

I think you now have a massive advantage over other manufacturers. We have already received feedback from several big customers that they were going to buy Takara Belmont but saw your products could be configured online and went with REM instead.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

Showrooms and training

What is the most important task you need to perform when using the REM product configurator?

Teaching sales staff about REM products

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
		x		

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
		x		

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		x		

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
		x		

What haven't we asked you today that you think would be valuable for us to know?

Makes life easier when explaining the REM product range to new sales staff. More of this please!

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

Website, showroom, sales staff and training.

What is the most important task you need to perform when using the REM product configurator?

How driven large growth in the amount of traffic coming to REM products on our website.

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			o	

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
			o	

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
		o		

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
				o

What haven't we asked you today that you think would be valuable for us to know?

This tool is far more important to your future than any of the other marketing you create. I'd go with this over the REM catalogue any day of the week.

REM

REM Wholesaler Questionnaire - 15/10/2019

Are you using the REM product configurator, and if so how?

We use it in showrooms

What is the most important task you need to perform when using the REM product configurator?

Showing customers different colours on different products.

How would you score your past and current experience with the REM product configurator?

Terrible	Bad	Okay	Good	Excellent
			o	

How does the REM product configurator score on ease-of-use?

Terrible	Bad	Okay	Good	Excellent
				o

How would you score the REM product configurator on accessibility? *(How easy it is to find and use)*

Terrible	Bad	Okay	Good	Excellent
			o	

How important will the REM product configurator be to your future sales of REM products?

Useless	Unimportant	Okay	Important	Crucial
				o

What haven't we asked you today that you think would be valuable for us to know?

Me and my team will be using this tool all the time. One thing that could be improved would be to include the dimensions of products on the configurator webpage. It's the only datapoint that you still need the catalogue for, if you added it to the configurator we could throw all our catalogues away!