ABSTRACT
This paper describes a project involving an extensive investigation into the manufacturing methods utilized by businesses’ seeking spectacle within the context of themed interactive physical environment’s. Two manufacturing methods in particular are in question as they have fairly similar processes, 3D printing and CNC machining. One process is additive, the other is subtractive. The paper begins by observing the theoretical ground-works of spectacle, archetype, and co-operative inquiry, including how they are used by media culture, and consequently in themed interactive environments. Subsequently a critical examination of key exemplars is described, analyzing the processes and methods used to produce an understanding of not only the current industry but to expose the successes and failures of the manufacturing methods under investigation. Finally the studio methods and processes for the projects physical interrogation are revealed. From developing and capturing the likeness of an on-screen iconic creature and the digital modeling processes involved, to research and testing of materials, production speeds, programming and operation of machinery. Reaching a physical outcome that displayed both processes involved, enabling the realization of a full-scale sculpture and miniatures intended for the themed environment. The project identified subtractive manufacturing’s superiority in contemporary society over additive manufacturing processes contextually grounded in large-scale themed environments and props that seek spectacle.

Categories and Subject Descriptors
• Human-centered computing ~ Human computer interaction (HCI) • Human-centered computing ~ Virtual reality • Human-centered computing ~ Visualization

Keywords
Virtual Characters; Digital 3-Dimensional Construction; Digital 3D Design; User Immersion; Human Computer Interfaces.

1. INTRODUCTION
The arts and entertainment industry have generated a plethora of avenues which deliver spectacle to their chosen audience. Theme parks, museums, and public art sites are locations seeking to immerse visitors by placing them in an environment which facilitates both suspension of disbelief through fantasy worlds informed by film, nostalgia, and popular culture. An integral aspect of this experience exists within the props and sets produced by subtractive manufacturing processes (CNC Machining). As a designer, this research seeks to pursue the viability of subtractive manufacturing within this environment in the wake of an increasing shift towards additive manufacturing (3D printing). This project will expose these processes and compare and contrast the advantages and disadvantages. Therefore the central question informing this research is: ‘How can the notion of ‘spectacle’ be delivered for the themed environment through a subtractive manufacturing process over additive methods?’ Within the context of these three industries that seek spectacle, my hypothesis would be that subtractive manufacturing should remain not just relevant, but a superior source of production until such a time that additive processes can become a financially viable option for projects seeking spectacle.

Each method has its advantages and disadvantages. In the near future CNC machining is likely to be superseded by 3d printing, and to clarify whether or not its limitations would extend the lifespan of subtractive manufacturing benefitting those working on projects that seek spectacle within the themed environment.

The first section looks at the theoretical frameworks used in my approach, analyzing Guy Debord’s Spectacle Theory, and Joseph Campbell’s theories on archetype. It will also focus on the research methodology of action-based research grounded on John Heron’s theory of co-operative inquiry. Specifically investigating how these frameworks and methodologies can assist in the development of creating objects of spectacle.

The second section analyses crucial texts and images from industry exemplars such as WETA Workshop, Legacy FX, and several others that hold relevance to this project. Anticipating these key sources will reveal how processes have changed and evolved, how these exemplars came about their successes and failures, creating a foundation of principles to approach the studio project with. The final section delves into my personal studio research of both 3D printing and CNC machining with an integrated research and sculptural project. The process begins with digitally sculpting a maquette of an iconic design that is a part of both Hollywood pop culture and palaeontology, the raptor from Jurassic Park. This digital maquette is then produced at a smaller scale with additive manufacturing as a diorama of spectacle, and then to full scale with subtractive manufacturing.
displayed in its raw form. Conclusively this will illustrate both processes and their strengths and weaknesses in producing objects of spectacle.

### 1.1 Media Spectacle

Theme parks and museums are sites utilising themed environments, seeking to entice the masses in order to generate a profitable outcome. In correlation to a capitalist and consumer-led society, these sites play a large part within the realms of mass media in an experiential form. The purpose to enter these places is to shift our perception of reality, and to ignore the real world, even for a moment. In other words, these sites seek 'spectacle'. But what is spectacle, and why is it beneficial to these areas? Spectacle theory, or 'spectacle' was a term coined by French theorist Guy Debord. In his book Society of the Spectacle, it is theorised we as consumers are detached from reality and are unable to perceive the true world, unable to distinguish fantasy from reality [1]. 'For Debord, the spectacle is a tool of pacification and depoliticisation; it is a 'permanent opium war' which stupifies social subjects and distracts them from the task of real life' [2]. Debord's view of spectacle does propose a negative outlook upon mass media culturally and socially. However spectacle seizes audiences and generates power and profit. From a business standpoint, spectacle is a fantastic tool to be used for manipulation and exposure as it is rife within mass media and a large influence on the consumer-led society we live in.

Critical analysis from professors such as Donald Kuspit, and Dougalas Kellner, discuss the many views one can take on spectacle. Kuspit views that ironically spectacle in terms of art, actually liberates it in a way as the capitalisation of it allows it to be experienced as something extraordinary, becoming a spectacular commodity itself, enabling it to survive in an industrialist culture [3]. Kellner views the influence of spectacle within media culture, and it's forever shifting forms as technology progresses over time. His interrogation into media spectacles exposure of contemporary global society identifies positive features. Kellner comments that 'media culture proliferates ever more technologically sophisticated spectacles to seize audiences and augment their power and profit' [4]. This is something that stakeholders within the entertainment industry are seeking to exploit, especially within the context of themed environments. He even goes as far as to theorise that spectacle is becoming one of the 'organising principles of the economy, politics, society and everyday life' [5]. This leads to an understanding that it is crucial to achieve a sense of spectacle when attempting to successfully market commodities, especially when observing spectacle's domination over Hollywood films, product placement, and the over commercialisation of the entertainment industry.

A primary example of the circuitous nature of commercialisation and placement in film is Jurassic Park, where merchandise has been positioned clearly within several scenes. Colin Trevorrow, director of the recent fourth instalment stated in an interview that "Jurassic World is based on Ian Malcom's quote, 'you stood on the shoulders of geniuses to accomplish something as fast as you could, and before you even knew what you had, you patented it, you packaged it, and slapped it on a plastic lunchbox, and now you wanna sell it!' That to me is Jurassic World, and that's why I had all the product placement' [6].

It is the perfect example of media spectacle as the franchise holds new relevance with its recent instalment, and Trevorrow really doesn't hold back on commercial placement either with one of the main locations of the film labelled as the 'Samsung Innovation Centre'. Malcolm's quote speaks volumes within the context of not only spectacle, but the project as a whole as I stand on the shoulders of others to achieve my goals, who in turn also stand on the shoulders of those before them. Consequently these points of relevance to the theoretical framing connect, therefore enabling the project to which I could explore the manufacturing methods in question. This leads to the point as to why the choice was made to develop a sculpture based on an iconic creature from the franchise.

### 1.2 Capturing Archetype

The initial steps of the project involved developing and capturing the likeness of an on screen creature of science fiction, and building a understanding of the semiotics (the visual signs and cues that build connotation) behind archetype which enable suspension of disbelief and consequently accomplishes spectacle.

Joseph Campbell has many written works regarding myth and archetypes, in particular the 'mono-myth' in his book The Hero with a Thousand faces [7]. Albeit Campbell's works revolve around 'the hero's journey', his views on myth and archetype assist comprehending his deconstruction of character archetypes. These ideals of 'monomyth' have been used in storytelling, and character design for many projects directed towards the general consumers of mass media. Many films, such as the Star Wars Saga, The Matrix trilogy, Batman, and Indiana Jones have all been influenced and shaped by these notions of archetype and the 'heroes journey'. These semiotic foundations have been applied to their character development and design, resulting in extremely successful and iconic franchises that exploit media spectacle and culture.

His inquiry into myth and archetype has been beneficial in constructing an appreciation of what makes stories and films such as these dominant in alluring the masses and exponential amounts of income. George Lucas, the creator of the Star Wars franchise has stated that Campbell was a direct influence on his films and that if he 'hadn't come across' his works, he would 'still be writing Star Wars today' [8]. Statistics of the franchises revenue articulate its success, generating an immense $US27 billion since its inception in 1977 [9]. Most recently, the film Jurassic World was this year's highest grossing film, and third highest ever at a current total of $US1.6 Billion revenue from just theatrical release [10]. Upon analysis of this franchise also, it is evident that Jurassic Park also benefited from such underlying frameworks.

The archetype of the antagonist was immediately formed in the initial opening scene of the original Jurassic Park, we never saw the villain yet felt their aggression, power, and intelligence as it pulled a gatekeeper into its heavily fortified cage. Again later the film hints at the creatures speed and dexterity, yet is never shown. Only the movement of foliage, frightening sounds, and the dialogue exchanged between the films protagonists reinforce this unseen malice audiences could only imagine in their minds.

Finally towards the films climax we are introduced to what was an unfamiliar creature in the context of dinosaurs to audiences at the time, and one of the most suspenseful and iconic scenes in spectacle films to date. Cleverly, each visual aspect of what makes them intimidating antagonists is delivered, piece by piece. The characters snout expelling a jet of steamy air on the window of a door before gazing inwards intently searching for prey, its hand inch retractable claws on its feet tapping the ground in an attempt to lure the children out of hiding [11]. Suddenly the audience is able to grasp the size of these creatures, which appear even larger and domineering from the children's perspectives. If there is one
1.3 Co-Operative Inquiry

Within the context of a research methodology this work has primarily utilizing the method of Action research within my investigation. Specifically John Heron’s theory of co-operative inquiry, as it communicates with participants to work in research instead of analyzing external subjects [12]. This relates directly to my current approach to studio research, as I am collaborating with other individual’s in order to achieve my goals in terms of production and furthering my understanding of industries that seek spectacle. This involved interning and approaching several studios, and contacting experts within both the fields of subtractive and additive manufacturing. Eventually I was able to find myself within a situation as to where this project was achievable.

Examples in relation to the context of the project within this form of research can observed in the processes used by artists and senior designers at WETA Workshop, Andrew Baker, Christian Pearce, and Gus Hunter. They have undertaken projects such as designing the enormous character of Smaug and Godzilla for several feature films as well as many other characters, characters and environments. Their methodologies provide an insight not only into unique design and research methods, but their most contemporary works have involved primarily designing creatures of immense size. Scale is a significant factor of achieving spectacle within themed environments as it can be used to distort a viewer’s perspective, shifting their sense of reality [13]. This was something they endeavoured towards in terms of how their creatures appeared on film and in-person (discussed in chapter 2).

Their research dynamic relied heavily on a cyclical collaborative and reflective process in which different concepts would be assimilated together to re-enforce a design that embodies the archetypal qualities they were seeking with each form [14]. Application of this method in context to the project has involved working with experts in additive and subtractive manufacturing. I was able to work in a studio based on the Gold Coast which employs the methods of CNC routing to develop characters and themed environments for films, theme parks and other projects. Before work on this project even began, I had already solidified my position there as a primary digital 3D modeler and began gaining experience within the industry itself and learning how the business operates. The cyclical processes involved in co-operative enquiry has allowed my knowledge base to expand in terms of not only the manufacturing processes but learning how to approach conceptual projects, dealing with clients and employees, constant feedback, and requests for modification.

2. Analysis & Exemplars

In terms of critical analysis, there are specific industry exemplars who provide insight into the methods investigated by the project. These exemplars are not only leaders in their field in terms of manufacturing methods, but also in manipulation of media spectacle.

The first text investigated in terms of understanding the successful creation of objects of spectacle was The Winston Effect. The text uncovers Stan Winston studios, one of the most influential effects studios in the film industry over the last few decades (This eventually changed into Legacy Effects after Mr Winston's passing in late 2008). The journey, from its foundation, all the way through to projects being worked on as it was being published. Naturally the project focused on the section that covered the design and creation process for the dinosaurs in Jurassic Park, and The Lost World. Although Winston's processes didn't include additive or subtractive manufacturing, the book provides great insight behind the design processes involved.

The text itself involves heavy documentation of the studios methodologies at the time, and the author Jody Duncan does take some risks to bring to light not only the studios successes' but failures as well. What was achieved with the design and creation of the creatures had never been done before, and was the first time organic creatures were effectively created with not just practical effects but computer generated imagery as well. Examples of the risks and failures involved included Winston expanding his Studio and working on production for a year before he was offered the work, an instance when someone almost died when working on the enormously scaled T-Rex, and a dinosaur prop breaking the night before filming was to take place.

Contrary to general opinion, the design process for the creatures was scientifically based and grounded within palaeontology for the current time. Only two creatures were altered in order to achieve the archetype they were seeking for the story. One of these was the Velociraptor. For the film some artistic licence was taken to represent them as the main villains and were made larger. Amusingly the discovery of another dromaeosaur [16] (what is commonly known as ‘raptors’), the Utahraptor in the same year resembled their design in size and anatomy [10].

In light of this, this illustrated that massive risks are taken in order to achieve goals pertaining the creation of large scale objects of spectacle. However, it also exemplifies that he was able to overcome the tribulations he faced and reaped the rewards, winning an Oscar in 1994. Subsequently, Legacy Effects took advantage of CNC technologies in the creation for the onscreen dinosaurs in some scenes of the latest Jurassic film over CGI in order to allow actors to create a more believable and interactive performance [17].

2.1 Additive & Scale

Printed parts for props within the film industry do look spectacular, and are due their credit. However these are almost always printed in small sections and assembled. There have been attempts at producing large-scale objects with additive methods. A prime example of this is the 3D printed car built by Local Motors, a total of 48 hours print time is fairly commendable for something the size of a vehicle [18].

![Figure 1: 3D Printed Car](image-url)
Yet aesthetically the vehicle is unsuccessful, the print lines are visible and jagged and there is no sense of spectacle and finesse (Figure 1). This is due to the fact that the printer being used probably has a larger nozzle to achieve larger prints at a lower cost in a shorter amount of time. In a sense of practicality it's great for quickly manufacturing a vehicle frame, however within the scope of aesthetics creating a sense of spectacle that other vehicles it is unsuccessful. These methods however are being combined experimentally with others to produce one of a kind objects that are starting to see success in these areas such as the 3d printed Shelby cobra [19].

China has taken 3D printing to an even larger scale, printing the world’s first house, and apartment blocks. The process involves building up layers of concrete in the same method as a traditional 3d printer would, so far this has enabled them to erect walls and flooring for structures at a more cost effective rate. However the method is still experimental and not available for commercial use for at least a few more years, one researcher in California even mentions that "One should realize that initially 3D printing can build the basic shell of the building. There is much more that goes into a house” [20]. The design of these houses remains very simple, and industrial, and they are purposed towards low income or use as emergency shelters. It’s important to note that this production process is unable to produce roofing for the structures due to limitations, and arguably restricts the creation of complex forms.

2.2 Fire and Water

Large-scale interactive creatures, and environments are just a few of what WETA Workshop has created and offered to the world. A prime exemplar for the project, Richard Taylor and his team have worked on many fantastic large scale objects of spectacle, as briefly discussed earlier in section on co-operative inquiry. Though many studios keep their in-depth methodologies to themselves due to the competitive nature of the industry they are within, Weta has showcased some of their methods in regards to the construction of several projects; including the creature installations at Wellington airport in the celebration and marketing of the Hobbit films, and the Scale of War exhibition based upon the realities faced by those who fought at Gallipoli in 1915. In some short informative videos, pieced together by Weta themselves, we experience their processes, displaying an impressive array of 7 CNC machines all capable of working on 5-axis [21]. A larger than life Gollum, spectacularly enormous great eagles, and the dragon Smaug were all manufactured utilising the subtractive manufacturing methods employed there [22].

Gollum, a pivotal character from the Hobbit films, reaches out above weary travellers as they eat in the airports food court. His hand sprawling for gargantuan fish, gazing in delight at his next meal as the visitors below enjoy theirs (Figure 2). Accompanying him further down the building, closer to where departures can be observed. Gandalf the Grey wizard, rides upon the great eagles of the Misty Mountains. Their 15 meter long wingspan envelopes the roof, soaring above those who are about to take flight and join them in the skies. Yet a malice fingers close by, watching the comings and goings of those at Wellington International. Smoke rises from the ancient dragon’s nose as he peers through debris, ready to devour anyone who comes close at a moment's notice. Weta has achieved spectacle brilliantly within the space they were commissioned to install these objects within. Not only does the airport set visitors at a tourist point the moment they exit the plane, it successfully alters their reality as they are surrounded by these wondrous sculptures. Coherently this also serves the marketing of commodities advertised through such a franchise that relies heavily on spectacle.

The Scale of War exhibition does very much the same, however is meant to entice a different emotional response. Weta produced several large scale sculptures of actual soldiers from Gallipoli (Figure 3).

Review of the exhibition have led to statements such as ‘Combined with the historical material it adds up to the most powerful and engaging presentation of warfare I've ever seen in a museum. It's obvious the organisers have undertaken a vast amount of historical research. It's not only spectacular, it's intelligent and very moving’ [23]. Weta Workshop are a principal example of utilising subtractive manufacturing to achieve spectacle appropriately.

3. DESIGN & CREATION TECHNIQUES

Creating a sculptural artwork that delivers interactive spectacle and advances the suspension of disbelief within the realms of film and theme parks is an extensive process. Initially before beginning a project, concept art and reference imagery is collected before starting a digital sculpting procedure. My personal workflow in terms of producing a digital 3d model consists of interchanging between several 3d applications, each with different strengths and weaknesses.

The process for building a sculptural form like the raptor for this project begins with referring to as many images of the animal’s physiology and interpreted designs as possible. The original concept art and proposals by Mark McCreery that were used for...
the film Jurassic Park were a fantastic starting point to begin building upon. Once enough information and imagery is congregated, the blocking out process of building the model can begin.

Pixologic's Sculptris is a fantastic tool for creating the base forms of a digital model [24]. Sculptris allows the user to digitally sculpt upon, pull, contort, and twist a sphere into almost any shape desired. Using this tool and working with multiple spheres to create different objects, these objects can be arranged and altered until something that resembles the anatomy of the creature is created. Once the base model captures a strong silhouette and resembles the rudimentary forms of the concept, the model is then imported into Zbrush to fuse the mesh comprised of multiple objects together, and work on the re-topology to enable work on finer details such as skin textures, wrinkles and scarring [25]. Working on these features allows not only to add extra depth to the character, but also breaks up flatter areas so forms aren't lost due to a variety of lighting conditions.

To reach a higher level of engagement with the raptor maquette, it was important to make the sculpture the epitome of a predator. The creatures on film operate akin to pack hunters, similar to wolves or lions. Yet their anatomy is strongly based upon birds and reptiles, particularly as it is a dromaeosaur. The model required scale that ensured it represented the imposing and dominant antagonists discussed in Chapter 1. The large dexterous claws on its hands and feet, scarring across its body and mouth, powerful hind legs used for running at high speeds and jumping great distances, an open maw filled with sharp teeth signifying not only its carnivorous nature but a social intelligence as it calls for its powerful hind legs used for running at high speeds and jumping great distances, an open maw filled with sharp teeth signifying not only its carnivorous nature but a social intelligence as it calls for
disbelief. As a spectator archetype is something that we can relate to, it is the accumulation of fundamental traits in things that allow our brain to instantly associate characters or creatures in particular roles. This is equally true in virtual and real spaces. The use of such “spectacle techniques” can potentially enhance physical experience but may also be able to enhance virtual experience in environments like VR/AR [30-39].

To further enhance these visual cues beyond sculpting, the base model is taken into Mudbox, this then enables the use of its skeletal rigging system to modify the posture and stance of the maquette to imply movement and behavior [26]. Once the posing of the model is completed, it is then sent back into Zbrush for further alterations as the reposing of the model can create some undesired and unrealistic forms warping the mesh [27]. These adjustments are usually made to make sure that details such as muscle shape and textures do not appear unnatural. These aspects enhance the realism of the sculpture, as they ensure small nuances such as stretched skin, weight, muscle shape and compression, all appear naturally. Reference and imagination is used heavily at this stage. This is essentially a creature that no longer exists today and imagery taken from other living animals, and previous interpretations is utilized in order to accomplish a sense of realism (Figure 4).

Finally a base is created for the model using a similar process, enabling it to be suitable for production and exported as a stereo lithography file [28]. This file creates the path and co-ordinates required for a milling tool such as a CNC Router or a 3D Printer to be able to start its process.

### 3.1 Investigation Into Additive Techniques

How these themed objects and environments are designed and constructed is a forever evolving process with progressions in available technologies. The subtractive process of CNC Machining plays a large role in building themed environments, effectively cutting away at a block of material to achieve the desired shape and structure based upon a digital 3d model. A newer technology, in the form of 3d printing is looking to surpass the subtractive as a new process that can create objects additively, melting down materials and forming the object layer by layer. Subtractive methods if abused can waste a lot of material. Whereas additive fabrication barley wastes any at all, yet is comparatively more expensive due to material limitations.

Arguably 3d printing is still an incredibly useful technology, being able to prototype smaller objects quite quickly. Observing the methods used by Legacy FX & Sideshow collectibles, these two companies collaborated in order to combine the usefulness of 3d printing to multiple outlets. This involved taking a model used for on screen CGI and 3d printing a maquette at different scales which were then used a reference for lighting so it could fit in seamlessly with the backgrounds used on film. However they also used this maquette as a product which is sold as a collectible statue.

Consequently as part my investigation, 3d printing has essentially allowed me to prototype my model in a much smaller scale before endeavoures to construct the full size version. Limitations in materials is something to keep in mind, for example PLA filaments combine different materials, yet aren’t comparable to pure materials due to its low durability [29].

SLA, and SLS methods offer the largest building envelope so far. This process is unique compared to traditional 3d printing, in which a container of liquid plastic has UV lasers fired into it, curing the plastic, layer by layer. The machine then extracts the objects being created from the container. This allows complex forms to be created accurately, at a faster rate, however is more expensive than desktop 3d printers due to the intricate nature of the machines design and materials required [30].

Within the context of finances, costs were also investigated. Quantitative data in the form of receiving quotes from 3d printing companies enabled an understanding of how expensive additive prototyping is. As an example I uploaded the model to ‘iMaterialise’, scaled down to 30cm (1:6 scale) in height printed in resin, and the price was estimated to be within $2775.29 AUD.
Extrapolated to full scale the cost would be around $99,910.44. Granted alterations can be made to the file to save materials, and taking into consideration added costs of services provided it doesn't change the fact that subtractive manufacturing is a more financially viable option. The initial estimations of costs for the full scale sculpture were $1000.00 in materials, and they came to $645.00, with a total of $5770.00 if services were included.

Utilising the 3D printers available at Griffith University, test maquettes of the raptor and areas of interest were printed in ABS plastic to achieve an in-hand physical sense of the model, allowing for any adjustments to the final model in areas that may have been overlooked that aren’t as evident on screen as they are physically. This also served as a test to see if the digital file translates well to the physical processes involved as both technologies use similar pathing methods. Then a final test maquette of the full model was printed in different sections, assembled and cleaned up. This model is to serve as a concept piece, displaying what the full scale model would look like if it were completed for a themed environment (Figure 18).

3.2 Investigation into Subtractive Techniques
Once these preliminary steps were taken, the larger version of the model could begin production on a Thermwood 5-axis CNC Router at full scale. As the process is subtractive, it is vital that the model is split up into sections, this way smaller blocks of material can be cut and conserved. Polystyrene was chosen due to its light weight, and speed at which it can be cut. Due to the sculptures large size, splitting it into many parts was also necessary, as the overall piece itself is comprised of complex forms and to save materials. The longest cutting period was approximately 4hrs30mins (the torso section), each process involves a rough cut which engraves the material into the general shape, and then a fine cut which details it.

Preparing the machinery for cutting is also a complex task. Apart from programming as to how the tool cuts the foam, blocks of material have to be cut precisely down to the millimetre, then attached to the direct centre of the routers table to ensure absolute precision. Two blocks have to be cut for each piece, one provides elevation so the cutting tool doesn’t come into contact with the table, and the main piece sits on top ready to be shaped.

During the subtractive process, there were a few minor setbacks as expected. Occasional mishaps when programming the machine to cut a section, caused a handful of the cuts to fail, or in some cases damage the foam by having an incorrect toolpath set. These problems were easily rectified as they had been anticipated, and using injection foam to patch areas up was a quick solution. The programming process of setting up a CNC Router is a more time consuming and manual process in comparison to 3d printing, yet if done correctly can be advantageous as it enables optimisation through customisation.

Over two months, I would work in the studio daily for 9 to 11 hours at a time. Splitting the raptor into practical sections, programming each part, cutting the polystyrene required, preparing the machine, operating it, and cleaning up the excess waste. After all 24 sections had been created, the model was then assembled and cleaned up, sharpening any less visible details. Towering at 6 and a half feet, the full scale dromaeosaur and antagonist from one of Spielberg’s classics had been realised. (Figure 21).

4. CONCLUSIONS & DISCUSSION
Comparing subtractive and additive methods in terms of large scale projects that seek spectacle is important, as there has recently been a significant amount of attention placed on the fact that 3D printing has enabled us to print large scale objects such as cars and even houses. Yet when observing the results achieved by additive manufacturing within the context of spectacle, the success of these things only goes so far. Observing the results achieved by exemplary studios in terms of subtractive manufacturing within that same context has illustrated the strengths and achievements of such methods. This projects physical investigation into both methods has also strengthened this argument, discovering how large scale objects of spectacle can be achieved with subtractive manufacturing.
Not only did the project run as expected, it was achieved in an incredibly short amount of time. My learning of the industry as a whole, expanded beyond this particular investigation as time went on. By standing on the shoulders of experts who utilise these methods to accomplish something as fast as I could, other aspects of industry methods came to light.

This investigation has the potential to grow further, and even look into how these technologies could be combined to optimise production methods. Envision a machine that could print out the base form and material quickly at a low cost, and simply alternate to a subtractive process which details the result of the initial additive process. Projects mentioned earlier such as the 3d printed cars could definitely benefit from a process such as this. Naturally industry leaders are headed in this direction, with Thermwood recently announcing their own plans to develop such a device [31].

Conclusively this project has justified the superiority of subtractive manufacturing over additive methods, within the context of themed environment’s seeking spectacle. Analysis of methods used by exemplary studios, research into financial comparisons, physical investment into how these technologies came to light. This investigation has the potential to grow further, and even look into how these technologies could be combined to optimise production methods. Envision a machine that could print out the base form and material quickly at a low cost, and simply alternate to a subtractive process which details the result of the initial additive process. Projects mentioned earlier such as the 3d printed cars could definitely benefit from a process such as this. Naturally industry leaders are headed in this direction, with Thermwood recently announcing their own plans to develop such a device [31].

5. REFERENCES