Reconstructing the Past for the Future: Denmark Vesey's Charleston as a Case Study in Building a Sustainable Digital Model

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RECONSTRUCTING THE PAST FOR THE FUTURE: DENMARK VESSEY’S CHARLESTON AS A CASE STUDY IN BUILDING A SUSTAINABLE DIGITAL MODEL

A Thesis
Presented to
the Graduate Schools of
Clemson University and the College of Charleston

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Historic Preservation

by
Matthew Amis
May 2018

Accepted by:
Dr. Carter Hudgins, Committee Chair
Amalia Leifeste
Dr. Brent Fortenberry
ABSTRACT

Our capability to digitally recreate the past in the form of three dimensional modeling has exponentially grown in the past thirty years. This growth is both welcome and problematic to the heritage sector. How to utilize this technology in a sustainable manner has become a central discussion in topical literature, and identifying methods to produce historic resources that remain useful and accessible as technology evolves is becoming increasingly more important. This thesis explores existing digital heritage models to establish keys to crafting sustainable resources within the field. An in-depth review of modeling software is presented with particular focus placed on the capabilities and applications of Revit, 3DS Max, SketchUp, and Rhino to heritage professionals. Utilizing SketchUp, this thesis lays the ground work for the digital reconstruction of Charleston, South Carolina in 1822, as a digital representation of the life of Denmark Vesey. Focusing specifically on two locations, each phase of construction is described and represented to allow it to serve as a point of reference to any heritage professional interested in creating their own sustainable digital resource. Focus on two sites pertinent to telling Vesey’s story also affords this thesis the opportunity to explore different methods of visually representing ambiguity within digital reconstructions.
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CHAPTER ONE
INTRODUCTION

As technology continues to exponentially develop and evolve, so too have our capabilities to digitally recreate history. With increasing fervor and enthusiasm, historians and archaeologists alike have turned their attention to modeling historic resources. This undertaking is not only to gain a deeper understanding of what they are studying, but also to better engage and inform public audiences and other scholars as to what the past can teach us. The main issue faced by these highly researched, and usually laboriously created models, is sustainability. Digital reconstructions soon become outdated or irrelevant due to their content, accessibility, or software. However, with the right approach, research, and application, historic reconstructions can aspire to have extensive life spans and continue to offer a plethora of benefits to their users regardless of technological advances.

This thesis is centered around both researching and understanding the complicated topic of sustainability, and representing the lessons learnt from this endeavor in a working three-dimensional heritage model. To achieve this, following a comprehensive literature review, this thesis is broken up into two inter-related parts.

The first, starting at chapter four, focuses on the successes and short-comings of heritage models over the course of the past twenty-five years by identifying
individual models to analyze. The examples selected will represent the evolution of technology within digital heritage models, to best identify how, why, and if they have remained relevant and accessible as historic resources. This process of analysis is then similarly applied to the study of modeling software available to the modern day heritage professional. Specifically, this study is focused around identifying and evaluating four prominent software programs to establish their strengths and weaknesses as platforms for creating sustainable and useful historic resources.

The second part of this thesis is then committed solely to the process of constructing a three-dimensional heritage model to represent the information gathered from part one in a useful, coherent manner. Heritage models can be constructed and represented in a number of interesting ways. For example, a model of 1853 Richmond was created by the Digital Scholarship Lab at the University of Richmond to visually represent the scale of the slave market within the city.¹ This three-dimensional model was created to re-engage the public with an important period of the city’s history in a new and exciting way.² Comparatively, Locating London’s Past is an interactive historic map of London that illustrates an alternative direction digital heritage models can take.³ The two dimensional interactive interface

² The 3D map of 1853 Richmond was built around an existing historic map created by a visiting English painter named Eyre Crowe. His accounts of witnessing slave auctions combined with the creation of his map meant he gave the perfect platform to create a digitally modelled reconstruction around a significant and detailed primary source. Accessed September 25, 2017, http://dsl.richmond.edu/civilwar/slavemarket_cite.html
the model presents acts as a living digital resource that can be molded by the user to represent different layers of information visually.

As a case study, this thesis will create a three-dimensional, interactive model of 1822 Charleston, South Carolina, to represent the life of slave revolt leader, Denmark Vesey. Laying the groundwork for a larger project in the future, the construction phase will focus primarily on two particular sites. The model construction process will also serve as a reference guide to anyone interested in engaging in the creation of this type of digital resource, something that is currently unavailable in the public domain.

Completing a working heritage model will allow for the conclusions reached by this thesis to be tried and tested in a relevant case study, and any problems that may arise during the construction process having been identified. The primary ambition of this model however will be to serve as an archetype for sustainable reconstruction of historic cityscapes. The term “sustainable” is central to the direction and purpose of this thesis. It is defined as the ability a digital heritage model has to retain its intended purpose as it ages, despite technological advancement. There are currently no set standards for the sustainability of digital models as a resource in heritage, and the lifespan of these models vary dependent on the goals of their creators. This thesis advocates for future heritage models to be constructed with sustainability as a priority, representing the process of creating such a model through the case study of Vesey’s 1822 Charleston.
On a broader scale, there are some fascinating implications to consider that may arise when attempting to create digital historic resources. For instance, finding the best methods of visually representing missing information or ambiguity within heritage models would be an interesting area for this thesis to explore. If research is ill informed or poorly executed, the model could potentially do considerable damage to the historic environment through misrepresentation. In rare but severe cases, history can be incredibly warped to create what Henry Rousso describes as historical negationism. This involves someone purposefully distorting historical facts to create an almost pseudo-history that better suits their desired outcomes. In general instances, this is easier to spot, but as the reach of the internet continues to expand, information becomes cloudier. Sources become less reliable. This is why it is so central for historic reconstruction to be as objective and honest as possible with any potential ambiguity within a model. The longevity and sustainability of the reconstruction depends heavily upon trust existing between the patrons of the model and its creators.

Moreover, the changeable and semi-permanent nature of a digital model could be utilized to allow heritage models to succeed where books cannot. Our perception and knowledge of historical events is constantly shifting, and new information can appear at any time to forever alter our perspective of the past. Instances of this are abound, particularly in the field of archaeology. For example, James Deetz discusses

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In Small Things Forgotten a type of “Colono-ware” that had previously been identified and accepted as being of Native American creation, but in fact was later discovered to be African American. Digital models have the capability to grow and incorporate new information where books and textbooks are forced to lie stagnant until re-written. Exploring whether or not any existing heritage models have evolved in this regard will be an interesting point of observation during analysis.

On a broader, more theoretical level, there is a certain romance associated with establishing new ways to connect with the past. Few have said it better than David Lowenthal in 1985 when he wrote,

The past remains integral to us all, individually and collectively. We must concede the ancients their place... but their past is not simply back there, in a separate and foreign country, it is assimilated in ourselves and resurrected in an ever-changing present.

Never in history has the past been so vividly available to us, and through so many engaging mediums. The potential historic digital reconstruction has to re-affirm Lowenthal’s conclusion that the past “is not simply back there, in a separate and foreign country” is undeniable. The “ever-changing present” that he also speaks of is why reconstructing and digitizing history sustainably is so imperative.

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CHAPTER TWO
LITERATURE REVIEW

Digital reconstructions of historic buildings and places and the potential they hold to inform and educate draws on a wide range of technical abilities. The literature that pertains to digital reconstruction is, in addition to being quite recent, interdisciplinary and can be sorted into four categories. The first will evaluate literature in regards to why historic digital reconstruction is such an effective tool for educating and inspiring future research and discussion. Although a relatively new topic in regards to historic preservation and interpretation, there is ample discussion in academic and scientific circles to illustrate why it is so pivotal to focus modern day education around visual prompts.

The second section will involve a broad survey of the current dialogue between scholars from numerous fields who have had experience with creating or studying historic digital models. This will include scholarship pertaining to overarching theoretical investigation into the implications of recreating history, as well as the practical issues facing historians, architects, and archaeologists who construct such models.

The third section of this review engages with the ample scholarship surrounding the emergence of digital documentation as a new means of representing heritage. This includes topics such as GIS (Geographic Information Systems), and BIM
(Building Information Modeling) as this dialogue is closely intertwined with that of the field of historic digital reconstruction.

Finally, this literature review studies how the heritage sector has employed technology over the course of the twenty first century, and how the discussion around the longevity of these methods and resources has evolved. Understanding the current academic climate in these four sections of scholarship is vital to laying a stable foundation on which to begin the methodology for this thesis.

**Visualizing History as an Educational Tool**

Why do professionals in the heritage and educational sectors feel it is necessary to visualize history rather than rely on text based resources to convey a narrative or information? There is a myriad of reasons as to why this has become the case. The most logical answer to this question is that advances in technology have created new and exciting opportunities to explore history, and only in the past decade or so has quantifiable data become available to garner useful results.\(^7\) For instance, it has recently been argued that in the United States that around sixty-five percent of

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\(^7\) Many scholars have discussed advances in technology and its impact on education. In regards to virtual worlds, a useful starting point is the essay written by a group of Turkish professors supported by the national Scientific and Technological Research Council. Murat Coban, Turkan Karakus, Asiye Karaman, Fatma Gunay, and Yuksel Goktas. "Technical Problems Experienced in the Transformation of Virtual Worlds into an Education Environment and Coping Strategies." *Journal of Educational Technology & Society* 18 (1):37–49. 2015
the population are visual learners. This has led to the widespread use of visual and virtual resources to engage with students on a more effective level.

One of the more fascinating examples of the use of virtual worlds in academic environments is that of the program Second Life. This platform was developed in 2003 and consists of a virtual world where anyone who has the internet can create an avatar and explore and create within it. It has come to be used globally as a virtual classroom for many undergraduate courses, and many have argued that it is very successful as a teaching method. In his 2013 article in The History Teacher, Eric Morgan discusses his experience using the program for an online course at the University of South Florida in 2011. Although accepting that the “potential for utilizing this as a medium in the history classroom has been largely untapped,” Morgan concluded that it offers “nearly limitless possibilities for both educators and students.” Despite some technical failures and issues with class discussion, Morgan found that his course on the Second World War was largely a success on Second Life. Following a midterm survey, he noted that “Seventy-six percent” of his students either “strongly agreed or agreed” that it had been a useful and informative

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9 Wagner James Au, The Making of Second Life: Notes from the New World. (New York: Harper Collins, 2008). This source is useful to gain a basic understanding as to how Second Life is used and came into prominence. Very subjective book written by a journalist to illustrate what life is like using the software for anyone interested, not written as a contributing piece of academic scholarship.
experience. The sizeable amount of academic discussion into Second Life as a program and educational resource, but that generally falls outside the scope of this literature review. The main takeaway from Second Life as an example of educating through a digital medium is that this format can be an effective, engaging, and accessible way of teaching.

In contrast to platforms such as Second Life, numerous efforts have been made to use digitally created historic models to engage and teach history as an alternative format to lectures and textbooks. Lynne Kvapil published an article in The Classical Journal in 2017 examining the potential use of a virtual recreation of Ancient Rome through the lens of “Problem Based Learning.” Kvapil’s case study and exercise juxtapose that of Second Life in the way that the model used for Kvapil’s experiment was created with a degree of architectural, historical, and archaeological accuracy compared to the open and unrestricted world of Second Life. Kvapil wanted to create “real world” problems in Ancient Rome for the students to answer in the hope that this would aid in information retention as well as make the course more interesting and engaging. Using a digital reconstruction of Hadrian’s Villa, students learned about Roman life, architecture, culture, and politics. Unlike strictly architectural models, and in a similar vein to Second Life, Kvapil’s students engaged with each other as well

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13 Morgan’s article is a great place to start when looking for further reading into Second Life, but another good source of scholarship around Second Life being; Thomas M. Malaby, Making Virtual Worlds: Linden Lab and Second Life (Ithaca, NY: Cornell University Press, 2009).
as computer controlled characters. Using quizzes to gauge information retention and collect data, the information gathered from courses at Xavier University and the University of Virginia suggested that the “virtual villa not only engaged them in the study of imperial Rome, it made them feel as if they themselves were part of the ancient world.” Again Kvapil noted issues with the technology throughout the courses, as well as logistical problems that face many new untested teaching techniques, but the example again illustrates a positive outcome when history is visually represented in an immersive format.

The literature surrounding the issues faced by educators and scholars when employing digital or virtual worlds as a teaching medium is extensive and equally as significant to the dialogue stemming from the topic. A collaborative article in the Journal of Educational Technology & Society from 2015 tackles some of these issues and highlights the potential threat an unregulated industry in terms of quality, accuracy, and price would have on digital reconstructions ability to be a useful educational tool. The article separates itself from other literature regarding the topic as not only was it compiled by a number of reputable professionals in education and technology, but it offers solutions to the issues it identifies. Interestingly, the article

highlights the willingness of educational institutions to invest in new and innovative technologies such as virtual reality platforms, and how that has caused prices to rise and create a challenging economic climate for the industry to develop.\textsuperscript{18} The authors also concur with Kvapil and Morgan’s articles in regards to the challenges faced when collecting and evaluating data to judge the success of these programs, as it would take a substantial amount of time to truly gauge how much information was retained. It is also made clear that the technology is still in a phase of constant development so glitches and crashing of the software during interaction were commonplace, although generally not completely damming to the user experience.

**Historic Digital Reconstruction**

The educational impact that visualizing and recreating history has had and can potentially have is immeasurable. The main scope of this thesis however lies on the top end of the spectrum of digital model making, and focuses on how technology has taken hold in the fields of archaeology, historic preservation, and architectural history. Within this smaller more specific genre of digital modelling, emphasis is placed upon accuracy, objectivity, and transparency.

A lot of the literature pertaining to cultural heritage and its correlation between digital modeling has emerged in the past decade, particularly from the field

\textsuperscript{18} Coban et al., "Technical Problems Experienced in the Transformation of Virtual Worlds into an Education Environment and Coping Strategies." 37
of archaeology. Unlike many vernacular and regional topics of research, scholarship regarding digital modeling in heritage is truly a global collaboration. One of the more recent textbooks to emerge in the sector is by three professors from the University of Catania in Italy, who posits that modeling is above all a:

methodology of recording all the archaeological data in a much more complete way than traditional photography and drawing and it is also an instrument of interpretation for the researchers who are involved in theoretical reconstruction of the past itself.

Their textbook *Digital Imaging for Cultural Heritage Preservation* represents a growing movement in the past ten years of methods and guidelines regarding technology in heritage being formalized and streamlined into literature.

Moreover, cultural and historic sites of national and international importance have turned to modeling as their newest form of interaction and interpretation. For instance, the governing bodies behind the ancient city of Anuradhapura in Sri Lanka which is listed as a UNESCO world heritage site, have turned to visualization as a new

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19 Examples of archaeology and technology working in tandem can be found in most articles, journal entries, or text books in relation to digital heritage and technology. One that stands out in use due to its accessibility (free to the public online) is that of one in the journal on image and video processing: Simon Haegler, Pascal Muller, and Luc Van Gool. "Procedural Modeling for Digital Cultural Heritage." *Journal on Image and Video Processing*, no. Special Issue on Image and Video Processing for Cultural Heritage (February) 2009. https://link.springer.com/content/pdf/10.1155%2F2009%2F852392.pdf

20 The sources included from this literature review are from all over the world and often written by multiple authors. This is predominantly due to the fact that the preservation of cultural heritage is a worldwide endeavor and sharing information and techniques has become incredibly valuable as more platforms emerge to share it.

way of expanding visitor understanding of the historic ruins.\textsuperscript{22} The article the that the architects of this project created for the \textit{Journal of the Royal Asiatic Society of Sri Lanka} was successfully created to prompt academic discussion as to how digital possibilities can open up heritage sites such as this to a new level of interpretation. Similar efforts have been undertaken at Angkor Watt and Hagia Sophia to name just a few examples, which further illustrates how fundamental digital modeling has become to historic sites around the world.\textsuperscript{23}

Capturing whole cityscapes or historic districts proposes a significantly greater challenge than simply recording an artifact or building.\textsuperscript{24} Literature has emerged since the turn of the twenty first century warning against these developing issues, predominantly in journal articles and symposium papers. \textsuperscript{25} When reconstructing on any scale there will always be a level of uncertainty in the absolute


\textsuperscript{23} Digitalization efforts at Hagia Sophia are mentioned in a comparative piece from the 2006 conference on virtual reality in Cyprus: Sabry F. El-Hakim, George MacDonald, Jean-François Lapointe, Lorenzo Gonzo, and Michael Jemtrud. 2006. “On the Digital Reconstruction and Interactive Presentation of Heritage Sites through Time.” In \textit{VAST 06 Proceedings of the 7th International Conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage}, 243–50. Nicosia, Cyprus: Eurographics Association. An in depth survey into technology and preservation at Angkor Wat can was written by; Roland Fletcher, Ian Johnson, Eleanor Bruce, and Khuon Khun-Neay ”Living with Heritage: Site Monitoring and Heritage Values in Greater Angkor and the Angkor World Heritage Site, Cambodia.” \textit{World Archaeology} 39 (3):385–405. 2007. Both are good supporting examples of heritage sites around the world adapting to technology and making themselves a more accessible resource worldwide.

\textsuperscript{24} A highly useful comparative study was written in 2014 discussing the problems faced by scholars or industry professionals when trying to capture whole cityscapes: S.P Singh, K Jain, and V.R Mandla. “Image Based 3D City Modeling: Comparative Study.” \textit{International Archives of the Photogrammetry, Remote Sensing and Spatial Information SciencesXL-5:} 537–46. 2014

\textsuperscript{25} Due to the fact technology has only recently allowed us to model 3 dimensionally, and with accuracy, there is not much literature outside journal articles in this area. Journals are the logical breeding ground for discussion in the field of 3d modelling as with every issue a new reaction or discussion can emerge to build on or counteract one from previous volumes.
accuracy of the model compared to its real life predecessor. When this reconstruction takes place on a city wide scale this uncertainty is unavoidable. The literature available in regards to how to communicate this ambiguity is still evolving and is certainly an area that needs more emphasis and attention as scholarship in this field grows. One of the more informative articles on the topic can be found in the Journal on Image and Video Processing written by three European computer science professionals in 2009. Formatting the article as a research-based examination of digital cultural heritage with supporting case studies is effective in giving their hypothesis credibility. Haegler and his colleagues open the article by highlighting the multi-faceted problems reconstructing uncertainty poses when modelling, in particular the notion that the “more compelling a reconstruction is, the more the general public may take the correctness of every detail for granted,” even if these details were based on no more than a “dedicated guess.” Among other things, the article then goes on to touch upon the importance of highlighting to the user of the model which parts have been procedurally produced compared to those which have been manually created.

The discussion as to how and why a concerted effort should be made to streamline the digital cultural heritage industry is also heavily addressed in a 2009 article in the Journal on Computing and Cultural Heritage. The three University of Virginia professors involved have a proven background in the digitization of cultural

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26 Haegler et all., “Procedural Modeling for Digital Cultural Heritage.”
27 Haegler et al., “Procedural Modeling for Digital Cultural Heritage.”
heritage, and use their expertise to address multiple issues facing the industry.28 The main topics covered include a dialogue about “digital rights management,” the need for a “centralized 3D cultural heritage archive,” and the need for “watermarking” 3D models to establish authenticity.29

One piece of highly significant literature that continually springs up in articles such as the one in the Journal on Image and Video Processing, is The London Charter for the Computer Based Visualisation of Cultural Heritage. The significance of this charter cannot be understated. It is the first concerted effort by the academic community involved with visualization of cultural heritage to establish professional standards for the construction of three-dimensional models regardless of their ultimate function. Conceived in London in 2006, the Charter aimed to tackle the issue of “intellectual transparency” and lack thereof in the field of visual cultural heritage, as well as gain more widespread recognition in the academic community for the field as a whole.30 The Charter is broken up into six principles; Implementation, Aims and Methods, Research Sources, Documentation, Sustainability, and Access.31 Although not recognized international to the level it ultimately hopes to be, the charter has been translated into 7 different language, been formally endorsed by the Italian

29 Koller et al., "Research Challenges for Digital Archives of 3D Cultural Heritage Models." 7.7.
Ministry of Culture as official industry guidelines, and been widely cited and lauded in publications around the world. On its second draft, and having inspired a similar charter in Seville which relates specifically to archaeology, the gap that existed in the academic community in regards to standards will continue to close.

**Digital Documentation**

There truly is a plethora of literature available as to the impact developments in technologies have had on our ability to document historic structures and artifacts more accurately and holistically. In many cases, the literature pertaining to digital documentation is interconnected with that of digital reconstruction, with the two only really diverging in regards to scope and their desired outcomes. Often the main goal of documentation is to record as accurately as possible an existing artifact, building, or ruin. The mantra of the heritage community world-wide has, since the inception of historic preservation as a concept, been to preserve significant cultural

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32 Although not formally recognized worldwide as the standard for the visualization of cultural heritage, *The London Charter* is an incredibly significant piece of literature in the field of digital heritage. Although mentioned in articles in journals such as the *Journal on Computing and Cultural Heritage*, a dialogue is yet to emerge as to how it should begin this expansion. Literature is most likely stale around the London Charter as it is a fluid topic as with much of the literature surrounding technology, and as it grows in popularity more will emerge.


resources for future generations. If preserving is un-achievable for one reason or another, then documenting has become the second best thing, and a task that has been progressively more formalized as the 21st century has continued. In juxtaposition, the goal of digital reconstruction is to recreate items, buildings, or cityscapes that are lost to us through similar methodology used in documentation, and the use of similar software. Due to the lack of depth in the literature about digital reconstruction, this distinction is usually lost in the text and the two are defined as one in the same.35

The fact that scholars are beginning to demand more information from their documentation methods is also a driving force in developing the capabilities of software to be more accommodating to reconstruction. The concept of “Building Information Modeling” has emerged in the past decade through this exact line of enquiry and its potential is still being fully explored in academic circles.36 A particularly useful article written for the Association of Preservation Technology in 2010 named *From HABS to BIM: Personal Experiences, Thoughts and Reflections* succinctly details this movement from a theoretical as well as technical perspective.

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35 To discuss one example of this further, Fabio Remondino and Alessandro Rizzi wrote an insightful article in 2010 for the Italian journal of photogrammetry and geography where they interchangeably discuss heritage documentation and recreation. This example is also particularly useful for understanding not only the methods of digital documentation, but real world examples of problems that may arise. Fabio Remondino and Alessandro Rizzi “Reality Based 3D Documentation of Natural and Cultural Heritage Sites - Techniques, Problems, and Examples.” *Applied Geomatics* 2 (3):85–100. 2010.

36 BIM is used in a variety of fields, America is a good example of a degree of standardization taking place to create standards within the industry. BIM has only more recently (2010 onwards) started to be utilized in the Heritage sector. There are many articles, particularly through historic sites or universities online that offer examples of this. From the international documentation conference in Edinburgh in 2012; C. Dore and M. Murphy, “Integration of HBIM and 3D GIS for Digital Heritage Modelling,” proceedings of Digital Documentation, Edinburgh Scotland, pg 22-23, 2012 http://arrow.dit.ie/beschconcon/13/.
It’s author, George Skarmeas, who has been elected chair of the US ICOMOS as well as Commissioner on the US Commission of UNESCO, uses his vast experience in the field to discuss how the creation of HABS in the 1930’s has evolved into our ability to create highly useful BIM models.37

The use of maps and a desire to view and document historic and cultural sites from a different perspective has also contributed to the development of digital modeling. Literature in the fields of geography, urban planning, archaeology, and heritage management is growing and discusses how the development of this technology has begun a new era in data collection and interpretation.38

The technology that has developed in conjunction with documentation and has had a significant effect on 3D digital reconstructions is that of laser scanning and photogrammetry. There is an abundance of literature detailing examples around the world of laser scanning and or photogrammetry being used to document cultural

37George Skarmeas personal profile found at his company website: http://www.pdparchitects.com/george-c-skarmeas/ accessed 10/21/17
resources and historic sites, and in many cases this documentation has led to reconstructions of parts of the subject or even the creation of original models.\textsuperscript{39}

Generally speaking, to reconstruct a historic site a great deal of documentation has to take place. Outside of the document based research, recording any and all physical remnants of the period, building, or artifact in question is fundamental to the accuracy of the model. The abundance of academic discussion around digital documentation reflects the growing emphasis being placed upon it as a field of study.

\textbf{Technology and Sustainably}

Literature around technology and the current capabilities of heritage models to survive technological advancement is sparse. In many journals and university articles the idea that models and digital resources should be adaptable and forward

\textsuperscript{39} There are many sources available and some that have already been mentioned that address the literature regarding to laser scanning and photogrammetry. The literature generally consists of case studies illustrating the documentation methods in action, rather than critique their ability. One book that addresses these emerging research opportunities, particularly in digital documentation is: Stefano Brusaporci, \textit{Digital Innovations in Architectural Heritage Conservation: Emerging Research and Opportunities}. Hershey, Pennsylvania: IGI Global. 2017. The article that included discussion on Hagia Sofía and the Warden article are incredibly enlightening when searching for a deeper understanding of these digital documentation methods. El-Hakim et al., “On the Digital Reconstruction and Interactive Presentation of Heritage Sites through Time.” Warden “Towards a New Era of Cultural-Heritage Recording and Documentation.”
thinking is mentioned as an inadvertent conclusion besides the literatures central argument.\textsuperscript{40}

Warden describes in his 2009 article in the “APT Bulletin” how “Documentation of cultural heritage over the last ten years has been dominated by development of digital tools.”\textsuperscript{41} When looking back further over the course of the past 50 years of technological advancement in the heritage sector, it is safe to assume that the rate of development of digital tools and capabilities will continue to speed up.\textsuperscript{42} With this in mind it is surprising that more attention is not paid to the adaptability and sustainability of digital resources.

There is a clear void within topical heritage literature regarding how to deal with the challenges associate with creating and maintaining an interactive digital resource. Filippo Stanco and his colleagues from the field of computer science define the publics potential to experience heritage into “passive and active forms of interaction,” in their book, \textit{Digital Imaging for Cultural Heritage Preservation}.\textsuperscript{43}

\textsuperscript{40}It is worth noting, the London Charter includes “sustainability as its 5th principle for computer based visualization of cultural heritage. Breaking this principle down into four main criteria, the charter posits that the “most reliable and sustainable form of archiving” is crucial to the resources longevity. That the data, rather than the medium it is stored on should take paramount over all efforts. That 2 dimensional documentation should also be included when possible to cover for technical failure or malfunction. Finally, that documentation strategies “should be designed to be sustainable in relation to available resources and prevailing work practices.” A lot of the literature covered in this review touches on this principle in one of the four ways listed, but not so much with a discussion based approach, rather a statement of necessity. Many articles take it as common sense that archival priorities lie with the data, but many omit the notion that digital resources should be stored or displayed with future migration to other platforms and software in mind.

\textsuperscript{41}Warden “Towards a New Era of Cultural-Heritage Recording and Documentation.” 10

\textsuperscript{42}The article previously mentioned tackling the “Research Challenges for Digital Archives of 3D Cultural Heritage Models,” has a very useful section on the history of virtual cultural heritage. Koller et al, “Research Challenges for Digital Archives of 3D Cultural Heritage Models.” 1.2.

\textsuperscript{43}Filippo Stanco, Sebastiano Battiato, and Giovanni Gallo. \textit{Digital Imaging for Cultural Heritage Preservation}. Boca Raton: CRC Press. 2
Passive forms of interaction apply predominantly to the study of sources and text, or the evaluation of data to form conclusions. Active forms of interaction on the other hand include creation and digitization of historic resources to become immersive, interactive experiences for the user. This “active” interaction with heritage is clearly becoming more prevalent but remains excluded from the mainstream academic discussion.
In order to establish how to craft a sustainable digital resource within the heritage sector, this thesis is broken down into two distinct parts. Part One is dedicated to tackling the issue of sustainability within heritage modeling and includes two chapters. The first researches past and existing heritage models to establish how well the models have maintained their original purposes over the course of their lifespan. The parameters for identifying these models are that they have to come from varying points of the past twenty years to establish a useful range of information, and that they have to be city-wide digital reconstructions of historic cityscapes. This method allows for some degree of uniformity across the models despite their difference in age. The number of models for this analysis will be limited to five to allow for a productive degree of research and analysis to be allotted to each model.

Having established keys to guide how one would go about producing a sustainable heritage model from the information collected, the next chapter focuses on the study of available heritage software. This will follow a similar format of identification and analysis, but will be represented in a format more suitable for future reference for anyone interested in researching software suitable for their needs within heritage. Four major software programs will be identified and conclusions will be drawn to establish both the capabilities of each software and their
abilities to create a product that can persevere and adapt to survive technological changes on the horizon.

Part Two of this thesis is focused around taking the information gathered from Part One, and representing its implementation in a working example. To this end, the decision has been made to create a digital model of 1822 Charleston, South Carolina, to serve as an interactive and educational resource as to the life of Denmark Vesey. There are a number of reasons as to why this has been selected as the working example of how to construct a sustainable heritage model, and they are addressed accordingly in Chapter Six. Part Two is broken down into the various phases of construction that are required to create a three-dimensional heritage model, again to be more conducive to being a reference guide to anyone interested in building such a model.

Each of the six phases of construction serves as an in-depth guide to the process required to produce a successful and sustainable heritage model. Each phase is further broken up into an Overview and Implementation section. The overview section details what this phase of construction would entail to anyone constructing a heritage model, regardless of its scope of topic, and the implementation section represents the practical implementation of said phase in the form of the Denmark Vesey model of Charleston.

Part Two is rounded out by a chapter studying three different methods of visually representing uncertainty within heritage models, before a review takes place of the construction phase as a whole.
PART ONE

CHAPTER FOUR

HERITAGE MODELING AND SUSTAINABLY

Digital tools have increased our ability to interpret, explore, and interact with historic sites and resources at an astronomical rate. The heritage sector has grasped these advances around the world, often to great success. As with all technology, however, the rate of change has caused unanticipated issues of sustainability. By the time one advancement in software or accessibility has been incorporated in the heritage sector, a new one has just as quickly arrived and made any digital models or resources created by “old” technology obsolete. Thus, when creating a digital resource every effort needs to be made to make it as sustainable and progressive as possible to ensure that time, scholarship, and skill invested in its creation is not wasted and it can continue to be useful and relevant as technology evolves. To achieve this, an effort needs to be made to understand the evolution of technology and its use in the heritage sector. Factors need to be identified to harden digital historic resources to be as prepared as possible to endure these technological advances.

The term “digital modeling” employed throughout this study, specifically references the process of three-dimensionally constructing a digital version of a building or historic landscape. When the phrase “sustainability” is used in this thesis, it should be interpreted as meaning the ability of a digital model to maintain its function as it grows in age.
Before focusing primarily on digital modeling it is important to appreciate how this issue is being faced across the world of cultural heritage management and interpretation. No branch of cultural management has been wrestling with the tyranny of rapid technology change more so than archivists and librarians who constantly face issues with storage, access, and outdated hardware. With world history up until the mid to late twentieth century being recorded primarily on paper, archivists have been facing the seemingly impossible task of digitizing these resources not only to make them more accessible but to ensure their information can be indefinitely retained for future generations. Huge and monumental strides have been made in this regard, and considering the effort that is being made to digitize history, equal thought needs to be placed on how to ensure this digital information will survive technological advancements that will inevitably follow. This issue is widely discussed in the academic community, and many archivists are becoming increasingly aware of the long term obstacles facing their efforts to store, protect, copyright, and make available digital resources.44 This is a conversation that needs to spread throughout the heritage community, as even a basic respect for best practices of producing or preserving sustainable digital cultural resources could go a long way in their longevity and effectiveness.

44 A particularly useful article in regards to considering the long term preservation issues faced by archivists is by Henry Gladney published by the Society of American Archivists. Gladney suggests that not enough is being done within the cultural management community to plan for the long term which he defines as 50 years or more. Henry Gladney, "Long Term Preservation of Digital Records: Trustworthy Digital Objects." The American Archivist 72 (2):401–35. 2009.
Turning specifically towards digital modeling in the heritage sector, a simple review of technologies and their mediums of representation illustrates the rapid rate of turnover that has occurred over the past few decades alone. Table 4.0 represents a list of selected heritage models produced since the year 2000 and juxtaposes their periods of use and how long it took for them to become irrelevant or in some case inaccessible.
<table>
<thead>
<tr>
<th>Resource</th>
<th>Year Created</th>
<th>Description</th>
<th>Sustainability Assessment</th>
<th>Function in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A Place in Time</em> by the University of Michigan Millennium Project</td>
<td>1999-2000</td>
<td>CD-ROM: Digital interactive model of the University of Michigan Campus.</td>
<td>Short period of use. Distributed via CD ROM for Windows 98. Cannot run on many modern day computers.</td>
<td>The model has since been transferred to the U.M campus history website where it is viewable in video form.</td>
</tr>
<tr>
<td><em>Visualizing Early Washington DC</em> by UMBC Imaging Research Center</td>
<td>2003-2011</td>
<td>Multi-Platform: 2D and 3D model created for a PBS documentary</td>
<td>Produced for a documentary, also a visual educational resource still available online.</td>
<td>Video still viewable on YouTube. Due to the quality of information it still retains a function today.</td>
</tr>
<tr>
<td><em>Paris 3D</em> by Dassault Systemes</td>
<td>2013</td>
<td>Multi-Platform: Digital interactive model of Paris throughout the ages.</td>
<td>Came out via DVD, book, and video format before being released on computer tablets.</td>
<td>Still accessible. Useful if the select time periods available are of interest. Full version only available via payment.</td>
</tr>
<tr>
<td><em>Virtual Williamsburg</em> by Colonial Williamsburg Foundation</td>
<td>2015</td>
<td>Online: Digital interactive model of Colonial Williamsburg</td>
<td>Requires a downloadable unity web-player to run. does not download on all computers.</td>
<td>Still serves its educational function. Program has since been dropped by C.W.F, jeopardizing its potential longevity.</td>
</tr>
<tr>
<td><em>Virtual Rome</em> by the University of Reading</td>
<td>2017</td>
<td>Multi-Platform: Digital interactive model of Ancient Rome.</td>
<td>Easily accessible online, offers a tour, walk through, video, access via mobile, and VR and AR.</td>
<td>At the peak of its use as it new. It's multi-platform design and ongoing ability to adapt and grow suggests it is in strong position to remain relevant and useful.</td>
</tr>
</tbody>
</table>

Table 4.0 – Table of Selected Models created within the past twenty-five years. Above are five digitally constructed historic models produced over the course of the 21st century, with the date of construction, a brief description of function, a synopsis of sustainability, and an evaluation of purpose in 2018.
The models used in Table 4.0 were selected as they are a good representation of the evolution of digital modeling in heritage since the turn of the twenty first century. They represent the use of the most sophisticated technologies for their period of creation, as well as a useful mix of mediums through which the models were made accessible to the public. Significantly, all the models are united by the fact that they are all three dimensional reconstructions of historic periods in time, as well as all representing a collection of buildings or in many cases a town or city. To understand how they have respectively aged over time and identify the reasons as to why or why not they have remained useful, a deeper study is required.

*A Place in Time* by University of Michigan Campus Historic Model

The University of Michigan released a CD ROM in the year 2000 to educate the public and academic community about how the campus evolved throughout the nineteenth century.45 It was created in conjunction with the “Millennium Project,” a research center at the University of Michigan concerned with the “impact of technology on our society, our communities, our institutions, and our planet.”46 This research center has aligned itself over the years with history projects concerned with

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45 Although released in the year 2000, the construction phase of the model took place in the late 1990’s. “University History Projects,” *University of Michigan Millennium Project*, accessed November 15, 2017. http://milproj.ummgu.umich.edu/

the universities history and continues to create resources today. Throughout the first decade of the twenty first century, it became fairly common for museums, historic sites, universities, and exhibitions to offer a CD or DVD version of their information or histories to both educate and provide a source of revenue.

![Figure 4.1 – ‘A Place in Time’ CD ROM](image)

*Image by author, CD ROM created by University of Michigan Millennium Project Team*

It is important to note the primary function of the model was to educate those interested in the history of the University of Michigan as to how the campus evolved through time. It was also created to provide visual support to the academic research the Millennium project had been undertaking, and to utilize the latest technologies available in 3-dimensional modeling. This information is important to note when studying the sustainability of such resources as the intention behind models creations are central to measuring sustainability. It could be argued that this particular model

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was not made to survive 5, 10, or 15 years, but rather created to stretch the technological boundaries of the time as an experiment and showcase.

The CD ROM was created with a handicap in regards to sustainability from the outset. Not only did users require a computer with a CD ROM/ DVD drive, it also required Windows 98/2K, the download of Quicktime™ 4.0, as well as monitor and RAM requirements. Although updates in software and hardware did not occur as rapidly in the early twenty first century as they do now, it would have been clear to the team at the University of Michigan that in the long run it was inevitable that the CD would ultimately be technologically outrun and made redundant. Therefore, a version of the model was also represented online in video form, adding to the models longevity.

Seventeen years on, the CD can still run on certain computers, but it is becoming more common place to see laptops (which are used by many as their primary computer) being sold without a CD ROM reader.

Figure 4.2 – ‘A Place in Time’ CD ROM home screen
Home screen of A Place in Time CD ROM where users select which year to view the model for the campus.

Screen-capture by author, content property of the University of Michigan Millennium Project.
Mixed results have been achieved from informal experiments to test modern day computers compatibility with the CD, by inserting it into a variety of computers. The majority of computers struggled to display the full interactive model while others failed to advance past the home screen. This is a result of the significant amount of change that has occurred in software used on computers in 2018, and representation of the life span of heritage models being accessed by CD’s coming to an end. The online version of the model is still accessible via the University of Michigan history website, but clearly serves the role of supplementary resource to those interested in campus history. Those interested in this information will still find it somewhat useful as a visual representation of other sources available from the same website, but ultimately in 2018 the model is outdated on almost every front.

In regards to the scope of this study, at almost twenty years old this digital model is a useful artifact of technology and offers good opportunity for comparison with more recent heritage models.

*Visualizing Early Washington DC by UMBC Imaging Research Center*

The multi-platform model created by the University of Maryland Baltimore County’s Imaging Research Center offers another fascinating perspective on the sustainability of digital historic models and its correlation to form and function. The

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48 This informal experiment was carried out on two main types of computer: a Dell OptiPlex 9020 with 3.4 GHz and 8 GB of ram, and a 2013 MacBook Pro with a 2 GHz processor and 8 GB of ram. On the windows based Dell computer, the disk would open up to the title menu, but fail to allow interaction with model. On the Macintosh based MacBook Pro, the home screen failed to appear.
project arose in 2003 due to the request for a virtual 1814 reconstruction of Washington DC for a “PBS style documentary” on Henry Latrobe. The video is now freely accessible via YouTube™ and the video format proved central to its ultimate formation and use. Taking another look at purpose, much like the University of Michigan model, it was created first and foremost for educational purposes. The fact that it is multi-faceted in information is also key to its ability to persevere through technological advances. It is a model of the capital of the United States in the early 19th century, with an added slant of detailing the life of a historically significant architect Henry Latrobe. A visual representation involving all these different points of popular interest means the model and video that it is represented in will continue to have the potential to attract anyone interested in these subjects.

![Visualizing Early Washington DC](image)

*Figure 4.3 – Home screen for the project website*
Screenshot from the website created by UMBC dedicated to this project.
*Screen-capture by author, image property of UMBC*

From face value observation of the model, it is clear that the visual quality and representation of this model is a step up from the University of Michigan model on a

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number of levels. Outside of the obvious technological advancements that had taken place since the end of the 20th century, the reasons as to the difference in quality are numerous. The archival sources available in regards to the history of Washington D.C are abundant and accessible, funding was readily available on multiple fronts due to the involvement of PBS and the scholastic community attached to UMBC, and the multi-platform representation of the model on television and online significantly adds to models chances of continual use. This project also expanded beyond the reasons that had primarily sparked the models construction, becoming a multi-year venture that spanned a number of years and historical topics.50

An interesting point in regards to sustainability that is introduced with this model is that there is a correlation between a resources ability to continue to adapt and persevere and developers or researcher’s commitment to continue to maintain and develop them. This model continued to have life and use as it had a continual supply of researchers and modelers who would develop new content and expand the models reach with blog posts and articles.51 It is certainly unrealistic to expect this kind of support and attention for every historic resource or model produced, but the creators of such models should consider how and who could take responsibility of the maintenance of the resource in the future.

50 The process of transferring the information from historic maps into the model itself prompted lectures and literature to be created by the Imaging Research Center at UMBC. Dan Bailey and Lindsay Shroader, “Visualizing Early Washington DC,” The Portolan, Issue 80, Spring 2011, 33-41.
Overall, the quality and depth of the information within the models created by UMBC’s Imaging Research Center mean that despite the ten years or so of software and technological development that has occurred since the models inception, it remains a useful source. The research and hours spent constructing the model would be a significantly useful starting point for any individual or group interested in modeling the early Washington D.C. landscape.

*Paris 3D by Dassault Systemes*

The third model listed in the table was selected for both its age, and creators. Unlike many of the other models included in the table, it was created by a for-profit, private company rather than an educational institution. This is significant for a number of reasons, but primarily because although it is an educational resource, it was created to become a source of revenue for Dassault Systemes. This effects the model as it was constructed to a whole new standard with far more ambitious requirements. Comparatively, the detail within the model is at a higher quality than the two previous examples, the ability to interact with the model is greatly improved, and the content within the model is also far deeper. It is a collection of models representing five different periods of French and Parisian history, all equally as detailed with the same amount of interactive capabilities.
This was also a “transmedia” project that was built by over “40 people” over the course of just over two years, which culminated in the launch of “a website, tablet application, a book, and an event.”\(^\text{52}\) The project was clearly ambitious on a number of fronts, and is one of the first examples of the shift that came with the second decade in the twenty first century which pivoted historic models towards having their programming as versatile as possible. As technology continued to evolve, people began to expect more and more from digital resources, especially when spending money to use them.

The graphics are a marked improvement over the models previously described, and a lot of effort was clearly made to create the most realistic landscapes as possible. There would have been further motivation to make this the case as by putting a video on YouTube in 2013 showcasing what the models have to offer, they

created a platform to advertise the product as well as illustrate the capabilities of the software they created and used to build it.

The intended lifespan of Paris 3D poses some interesting questions about the role time plays on the design and purpose of digital heritage models. It could be argued that this model was purpose built to fade out of reach from public consumption after a limited period of time. The model served its primary function and had been distributed on various platforms thus achieving its purpose of marketing the company to wider audiences. As time goes on and technology evolves, it could be seen in the best interests of the company to phase out use of the model in the event that someone thought it was the best they could produce with the latest technology. That being said, in 2018 the graphics, scale, and detail are all still fairly impressive and for the many people interested in French and Parisian history, the model is very useful. How accessible the model is due to the fact it was created for commercial purposes could pose a problem.

*Virtual Williamsburg by Colonial Williamsburg Foundation*

*Virtual Williamsburg* is an incredibly useful model to evaluate for a myriad of reasons. When evaluating its place on the spectrum of models since the year 2000, attention again has to be paid to its purpose, platform, and availability. By the time Colonial Williamsburg had decided to invest in a Digital History Center with a full time crew of modelers and technology professionals to pair with their pre-existing team of
heritage professionals, the use of technology and heritage was well established internationally.\textsuperscript{53} It is also significant as it marks the another shift in the purpose of modeling. Colonial Williamsburg is famous for its effort to reconstruct the colonial city as it once was in the 18\textsuperscript{th} century, and an opportunity was identified to use three-dimensional modelling to aid in the reconstruction process. Naturally, due to the educational purpose of the Colonial Williamsburg foundation, the model was used in a number of formats as it grew in quality and size.

In 2018, the models are readily accessible online as long as you download a program called “Unity Web Player,” and offer an immersive, interactive experience. This model remains a unique example of digital modeling in heritage because Colonial

http://research.history.org/research/digital-initiatives/
Williamsburg is a real life version of such reconstructions, so how would a digital model help add to the city’s interpretation? Apart from its use in aiding the reconstruction efforts, it offers perspectives unavailable to many visitors due to certain buildings being off limits or restricted in access. It also offers the team at Colonial Williamsburg to represent information in another dimension and format remotely and to anyone with a computer and internet connection, thus marketing their research and city to the world.

It is safe to say in 2018 that three years since its inception, the quality and accessibility of the model are still going strong. Such a detailed, well researched model certainly still has a place in the academic and professional world today, however the program has since been dropped from the foundations current business model. This significantly impacts the assessment of the models future prospects, and is an interesting representation of the fragility of these types of digital resources. Although the model will cease to grow and develop, as long as its point of access online remains unhindered it can still serve an educational purpose.

**Virtual Rome by the University of Reading**

The eternal city of Ancient Rome has and will continue to be a focal point of research and interest around the world. It has been modeled in numerous formats to varying levels of quality since technology has allowed such endeavors to take place in the late 1990’s to the present day. One particular example that has emerged very
recently is that of one by the University of Reading in England and their Classics department, particularly Dr. Matthew Nicholls. The model stands apart from the previous models for a number of technological reasons, making it particularly useful for representing the evolution of modeling throughout the 21st century.

![Virtual Rome](image)

*Figure 4.6 – The homepage of Virtual Rome*

Virtual Rome offers the most interactive experience of any model discussed, including VR, AR, and mobile phone interaction as well as the online model.

Screen-capture by author, image property of Virtual Rome and the University of Reading

The separating factor for this contemporary model in regards to sustainability is two-fold. First, not only is the model available online in an incredibly user friendly fashion, its contents are available on a number of platforms including virtual and augmented reality. Integrating the model with these two platforms is key to its sustainability, as these two forms of interaction have begun to significantly find their way into the heritage sector and will only continue to do so over the course of the

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54 “Virtual Rome,” *University of Reading*, accessed November 26, 2017. https://research.reading.ac.uk/virtualrome/
next decade.\textsuperscript{55} Secondly, the model is continually being added to in an academic environment through the University of Reading by both its creator and classes that pass through the program.\textsuperscript{56} The continued use of this model will add to both its accuracy and longevity.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4_7.png}
\caption{User interface for Virtual Rome}
\small The interface allows the user to take a video tour, insert themselves into the model to gain a different perspective, connect the model to a mobile device, and integrate the model to VR and AR friendly mediums.
\end{figure}

\textsuperscript{55} Many sources hint at the current technological direction cultural heritage is taking. Particularly in the field of augmented reality, where the system is being implemented around the world through the use of mobile phones. Yu-Lien Change et al., “Apply An Augmented Reality in a Mobile Guidance to Increase Sense of Place for Heritage Places.” \textit{Journal of Educational Technology \& Society} 18, no. 2 (April 2015): 166–78.

\textsuperscript{56} Dr. Matthew Nicholls, “Usage in Teaching and Outreach,” \textit{University of Reading, Virtual Rome}. Accessed November 28, 2017. https://research.reading.ac.uk/virtualrome/about/
*Virtual Rome* is an incredibly useful example of a model that has been created not only using the latest technology available, but preparing itself for the next latest technology that is yet to come. This represents a recent shift in digital modeling in heritage towards being adaptable and forward thinking, a quality that is arguably missing from earlier examples.

**Synthesis of Results**

There has undoubtedly been a vast number of three-dimensional models created over the course of the past twenty-five years, but these five models serve as a successful representation of the evolution of how and why these city-wide models were produced, and how they have held up over time. Identifying these trends is vital in establishing keys to sustainably creating models moving into the future.

Representing this information in the form of graphs and tables is the most effective and informative starting point for this analysis as it visually juxtaposes various elements of each model. This will include comparisons of the suggested life-span of each model, their intended purposes, the platforms they are available on, the models capacity to adapt and change, and the quality of information used and represented within each model. There is a degree of subjectivity to this analysis, as the models discussed do not necessarily have definitive life spans, nor is there a way to objectively measure the quality of information represented. Therefore, in the name
of transparency when a subjective conclusion is reached and represented it will be designated as such.

The first point of analysis is that of mediums of representation used to display the models over their life spans. This will aid in illustrating any mediums of representation that have proved sustainable since the turn of the 21st century.

**Figure 4.8 – Pie chart representing the amount of times a various platform was used to display the models created.**

This pie chart illustrates how every model that came under review has been represented online via a website.

*Figure 4.8* is a representation of how dominantly the internet has been as a medium of access and representation for historic digital reconstructions. Every single model analyzed used the internet and their own website to make available their model. This may seem obvious to many, but it is important to note because the
internet has not only remained a constant as a platform for sharing models such as these, but has continued to grow and develop over that period showing no signs of going out of use. Earlier digital models were created for release via CD ROMS or DVD’s, but models have since and continue to be built primarily for use and access online. Anyone attempting to build a 3-dimensional historic reconstruction of a city-scape will and should continue to base the construction of their models around being accessed and interpreted online. Moreover, YouTube™ is used to a significant capacity with four of the five models. The only model that is not represented on YouTube™ is the earlier constructed University of Michigan model, every model since included the use of YouTube™ as its secondary source of access after the creator’s website. This is again useful to understand prior to constructing a model, as finding a way to make a video to accompany the digital reconstruction to display on YouTube™ is clearly an effective marketing tool and method to spread the word of the models existence.

The remaining mediums included in Figure 4.8 represent efforts made to expand the number of platforms the models are available on. Most of these mediums tend to follow the latest technology of the era that the model is created. For instance, the University of Michigan model that was released in 2000 came out on a CD as that was a relevant and modern platform at the time. Moreover, the Virtual D.C. model followed its required function of being conducive to a television show, and the Paris

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57 Virtual Williamsburg, Virtual Rome, and Paris 3D use YouTube™ as a means of representing parts of their models, making it primarily a marketing tool. Particularly in the case of Paris 3D who use YouTube™ primarily for this purpose, displaying only a few minutes of a sneak peek as to their full paid models capabilities.
3D model was intended to be sold in as many forms of interaction as possible so was released in a book and mobile form. More recently, Virtual Rome released in 2017 is built to be accessible via the latest technology of Virtual and Augmented Reality. These trends of new technological mediums have supported the primary access point of the internet over the last 18 years. This suggests two interesting points; one being that the internet as previously mentioned should be the number one point of interaction and access, and two that to make the model relevant during its period of release it needs to feature the latest available technology to gain people’s attention. Either way, to produce a sustainable digital model it needs to be accessible on multiple platforms.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>A Place in Time</th>
<th>Visualizing Early Washington DC</th>
<th>Paris 3D Williamsburg</th>
<th>Virtual Rome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reconstruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td></td>
<td></td>
<td>搜狐</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>搜狐</td>
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</tr>
</tbody>
</table>

*Table 4.1 – Table representing the intended use when models were first constructed. This table illustrates that all the models constructed were rooted in some kind of educational purpose. A number of other motives have developed over the first two decades of the 21st century.*
One of the clear correlations that emerged through the analysis of the models respective capacities to endure was that of purpose and use. The model's life spans are clearly connected to the purposes of which they are built. If they were built to fulfill a certain requirement at the time, then the longevity of the model may not have been a priority after that is fulfilled. In addition, if a model is built for educational purposes and the research and scholarship behind said model is of a dependable and high quality, then that information could potentially continue to be a draw for attracting people to using the model.

The motivations for constructing all five models undoubtedly stemmed from education, albeit to varying degrees. This intrinsically creates a level of sustainability for the resource from its inception, as anyone with an interest in the information represented within the models will always find a degree of use in what the model is representing. Eighteen years on from the release of the University of Michigan Campus reconstruction, although the model is harder to interact with, access, and appreciate due to the graphics it could still potentially serve a purpose to someone interested in the history of the campus. The same can be said for all the models discussed. A significant factor that is harder to measure is that of the quality of the information represented in each model. How well researched was it? How accurate is the architecture that is represented? How much conjecture and guess work has been included in the model? How are these gaps in information represented? These are questions that are hard to externally measure, but are significant in determining why
or why not patrons and users of the models continue to find it relevant despite technological advances.

In regards to the other purposes included in Table 4.1, Virtual Williamsburg was established for both educational purposes and as a tool to aid in the reconstruction of certain buildings and areas of Colonial Williamsburg.\(^{58}\) It stands alone in this respect compared to the other models, but the theme of being constructed for multiple purposes is consistent across all five cases. Paris 3D by Dassault Systemes™ is the sole example of a model being constructed as a source of financial revenue, though it is important to note that the majority of models would have received funding of some sort throughout the process of construction. However, Paris 3D is separated by the fact that to view and interact with the model you have to make a purchase of some kind. This in an unsustainable approach to model making as creating any kind of obstacles to using the model detracts from its potential ability to be continually used. Four of the five models have also been designated as having a purpose of “Other” as other contributing factors existed as to the models inceptions and consequent use. Virtual D.C. was constructed for use in a PBS documentary, A Place in Time and Virtual Williamsburg were both partly created to push the boundaries of technology in heritage, and Virtual Rome serves as a platform to teach three-dimensional modeling.

<table>
<thead>
<tr>
<th>Retain Original Purpose in 2018?</th>
<th>A Place in Time</th>
<th>Visualizing Early Washington DC</th>
<th>Paris 3D</th>
<th>Virtual Williamsburg</th>
<th>Virtual Rome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully</td>
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<tr>
<td>Partially</td>
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<tr>
<td>Not at all</td>
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*Table 4.2 – Assessment of analyzed models ability to continue to fulfill their original purposes.*

Arguments could be made for varying results than this table depicts, but considering the information discussed analyzed, these results are academically defendable for a number of reasons.

Despite the educational purposes behind each of the models, this does not guarantee their continual use and relevance as technology evolves. As seen in *Table 4.2, A Place in Time* is judged to fail to fulfil its original purpose 18 years later, whereas the following two chronological models partially retain their educational purposes, with the latest two additions naturally retaining their functions due to their relatively recent inceptions. This table is not to suggest that the two newest models are more sustainable as they still retain their educational effectiveness, but more so to represent that time and the evolution of technology will diminish a models ability to fulfil its primary purpose. The digital reconstructions of the University of Michigan’s campus included on the CD *A Place in Time* may remain a useful representation of campus history, but if the model cannot be accessed or viewed as the processing system it runs on is outdated, the graphics un-inspiring or ineffective, and CD ROM’s obsolete as a platform what good is the model? *Virtual D.C.* encounters similar issues as the graphics have been overtaken, and the fact it has not been adjusted or
expanded upon for seven years leaves the model vulnerable on a number of fronts. As previously mentioned, Paris 3D is burdened by the fact that is requires payment for full access, and the chances of it becoming free are fairly limited due to the fact that a company that produces digital models professionally may only want to be represented by their latest and most innovative models.

<table>
<thead>
<tr>
<th>Built to Change over Time?</th>
<th>A Place in Time</th>
<th>Visualizing Early Washington DC</th>
<th>Paris 3D</th>
<th>Virtual Williamsburg</th>
<th>Virtual Rome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
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<tr>
<td>No</td>
<td></td>
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</tbody>
</table>

*Table 4.3 – Assessment as to whether the models were constructed with the intent to be adaptable and changeable in the future.*

When the model has been constructed by an academic community (in this case higher education), they were constructed to be added to and expanded.

*Table 4.3 is significant as it illustrates the fact that historically models have not always been built to last. There has certainly been a push in the second decade of the 21st century to become more sustainable in all walks of life, and this has bled into all aspects of human endeavor. In regards to how this relates to model construction in the heritage sector, why spend so much time and effort creating a resource if it does*  

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59 Broadly speaking, humans around the world are more conscious of being forward thinking across all aspects of their lives. This is represented academically in virtually every field of study, but the reasoning behind how this has potentially emerged on such a visceral scale is discussed at great length in many sociology journals. One of specific note appears in the Swedish Journal of Sociology. Tom Burns, "The Sustainability Revolution: A Societal Paradigm Shift — Ethos, Innovation, Governance Transformation." *Sociologisk Forskning* 48, no. 3 (2011): 93-108.  
not maximize its potential? Why not make it perform as many functions as it can? Why not make it to last as long as it can remain relevant and useful? Creating anything short of these standards has become frowned upon. Again, there is a question of purpose as some models may be created to fill a gap in academia or for a specific conference, commemoration, or time-frame. But even in these situations one must ask themselves if there is an opportunity for this to aid in someone else’s research or ambitions. Outside of YouTube™ numerous websites and platforms have emerged to share models and resources for this exact purpose. Sketchfab™ for instance is a website that anyone can join for free, but allows people in fields such as biology, architecture, art, culture, archaeology, and geography to name a few the opportunity to share and display their models for others to draw and build upon.60 They currently have a freely accessible database of over “2 million models,” making them (in their words) the “world’s leading platform to publish, share, and discover 3D on web, mobile, VR and AR.”61 When education and interpretation of history is the central driving point of creating a heritage model, there is as much of a responsibility to share it with others as there is to research and compile it properly.

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60 The centralization of three dimensional digital models into freely accessible databases offers a lot of benefits to both creators and consumers. A good example of a heritage model utilizing this type of platform, in this case Sketchfab, is Historic England’s collection of virtual tours of maritime archaeology sites. Registering the interactive models on a widely used public database such as Sketchfab could greatly increase the models potential reach, and in turn its potential sustainability. “Your 3D on the web,” Sketchfab, accessed November 29, 2017. https://sketchfab.com/?utm_campaign=nonbrand&utm_medium=cpc&utm_source=adwords&gclid=EAIaIQobChMIw6Lku8iB2QlJVXbxbACh299w2dEAYASAAEg5kPD_BWe. Grant Cox and Alison James, “England’s Protected Wreck Sites,” Historic England, accessed November 29, 2017. https://historicengland.org.uk/whats-new/research/englands-protected-wreck-sites/

As we need to collectively look back on the evolution of models in heritage to identify features we need to incorporate to model sustainably, we need to constantly be looking forward to best prepare what we create for what is on the horizon. Currently, the horizon in the heritage world is full of discussion as to the implications of VR and AR in our interpretation of heritage.62 *Virtual Rome* is a great example of a model not only incorporating the latest technology into a model, but preparing itself for what is coming to give the model the chance to remain relevant and useful over the next decade. On many cultural sites across Europe, technology firms have become increasingly involved in the practical implementation of Augmented Reality. 63 Leading the way in transitioning this technology to historic and cultural sites across the U.S. is a company named ArtGlass™ who offer wearable augmented reality glasses which have been a growing success across Europe.64 There is a long way to go in this technology becoming a staple in our interaction with historic sites and the past a whole, but the amount of investment and interest in this new technology is undisputable.65 Allowances need to be made when producing a digital heritage model for this kind of up and coming technology if it wants to remain relevant and useful.

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62 The topic of digital innovation and development within heritage was discussed at a number of sessions at the most recent National Trust for Historic Preservation conference “PastForward,” in Chicago, November 14-17 2017. One particular session named “What’s on the Horizon: Gaming, Podcasting, and Virtual Reality” hosted a panel of industry experts to discuss the latest technological innovations. Mariaelena DiBenigno, Nicholas Redding, Trish Smith, Khanh Vo, and Marion Werkheiser. “What’s on the Horizon: Gaming, Podcasting, and Virtual Reality,” PastForward 2017, Session #LTH180, Thursday November 16, 2017.


Moreover, there has also been a movement recently towards BMI models and the useful implications that models can have on the running and management of historic properties and sites.\(^6\) Naturally, there isn’t as much room for this function in a reconstruction as most of the sites are not in existence anymore, but if some parts of the model are then there could be reason enough to allow for the model to be adapted for this use in the future.

It is important at this point to briefly discuss what constitutes success in a models ability to be sustainable. With the rapid development of graphics over the course of the twenty first century, it has proven an almost impossible task for a purpose heritage built model to remain relevant for more than 5-10 years.

![Figure 4.9](image_url)

*Figure 4.9 – Bar chart representing the estimated life spans of the analyzed models. Virtual Rome and Virtual Williamsburg are represented in a different color as the estimations for their life spans are harder to measure due to their relatively young age.*

The public expectations for graphics have dramatically risen in conjunction with the ever reaching capabilities of graphics in animations on television, movies, and video games.\(^{67}\) Does this mean that a model seeing continually or periodic use over a 5-10 year period is a success? In Figure 4.9, the five models previously analyzed are judged to fall around this time frame for periods of relevance, in large part due to their ultimately outdated graphics and formats. The two current exceptions to this are *Virtual Williamsburg* and *Virtual Rome* as their graphics are still fairly relevant and acceptable by modern day standards, so their estimated life-spans are based more closely to their potential to adapt and evolve over time.

However, despite how ten years of use may be considered a success to some, it needs to become a minimum expectation. With the amount of time, research, and programming that goes into creating these city-wide digital reconstructions, accepting short term success would be doing an injustice to their potential. This is not to say that just because a lot of time has been spent on something it should last a long time, because that is not always true. But in regards to digital historic resources such as models, they need to stop being seen as temporary, and start being treated as if they are any other piece of scholastic research. Historians do not produce books and research articles to be useful for a few years, they are produced to add a new layer of

\(^{67}\) This is represented in a number of sources, particularly journal articles. One that captures the particular leap of graphics during the twenty first century is found in the *Scientific American* journal. W. Wayt Gibbs, "A Great Leap in Graphics." *Scientific American* 295, no. 2 (2006): 80-83. http://www.jstor.org/stable/26068927.
The fluid nature of technology may have scared historians, archaeologists, and architectural historians in the past but it shouldn’t have and by no means should continue to do so. Digital resources can and should be produced to endure and create a palimpsest of digital history within their respective fields. Finding alternative methods such as incorporating models into as many platforms of accessibility as are available, representing screenshots in academic journals and books, and or 3-d printing models to be physically interpreted are just a few ideas to expand a digital historic models potential life-span.

5 Keys to Creating a Sustainable Digital Historic Model

What are the lessons learnt from the data collected and represented in this section? A number of trends are clear and form the basis of creating five keys to crafting a sustainable, three-dimensional digital model within the heritage sector.

1. Any model created should be created with the highest quality of scholarship, so the information represented is reliable and objective. This scholarship should be available along with the model to establish accountability and create a rapport with the model users. Due to this academic integrity, the

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model can have the potential to continue to fulfill its educational purpose despite technological development in the future.

2. The model should be made available freely online via a website, as well as accessible on multiple platforms in varying formats. This allows global access to the model, as well as a source of background information to provide transparency. Moreover, it should be shared and promoted on numerous other online platforms that are both general and specific in their audiences.

3. The latest technologies and software’s should be utilized when the model is constructed. This includes mediums of representation. Currently in 2018, the latest technological trends emerging in the heritage sector focus around Augmented and Virtual Reality, and models are also made available through phones and remote devices.

4. Models should be constructed with multiple purposes. When so much time and effort is spent creating a resource of this magnitude it should be utilized to serve as many functions as possible. For example, a model should have the ability to represent a variety of layers of information rather than just one to expand its ability to attract more users.

5. A model should be built to adapt and change. Does the software being used allow for plug ins? Is the model user-friendly to allow for change in the future if something represented is proven to be wrong or new information comes to light?
These five keys can aid anyone interested in modeling within the heritage sector in making informed decisions during the construction process to give their models the best chance of enduring the fragile technological climate of the 21st century. As represented in Table 4.4, these keys can also be used as a tool to measure the potential sustainability of existing models.

<table>
<thead>
<tr>
<th><strong>Sustainability Key</strong></th>
<th>A Place in Time</th>
<th>Virtual D.C.</th>
<th>Paris 3D</th>
<th>Virtual Williamsburg</th>
<th>Virtual Rome</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Quality Research and Scholarship</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Availability/Access</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latest Available Technology Used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-Purpose</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Built to Adapt and Change</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Points /5</strong></td>
<td>3.5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table 4.4 – Sustainability assessment of assessed heritage models against keys to modeling sustainably in heritage.*

The score out of 5 represents the models’ ability to endure technological advances and remain useful as a historic resource. A clear box represents a full point, grey a half point, and solid zero points.

*Table 4.4* offers a means of measuring heritage models under construction or recently completed for their potential sustainability. Grey/ a 0.5-point measurement has been incorporated as it allows a means to represent partial fulfilment of a key. *A Place in Time* and *Virtual D.C.* received this grade for their online availability as they
are only available online in restricted formats such as videos or screenshots, losing their original interactive purposes. The same score has been awarded to *Virtual D.C.* for its ability to adapt and change as it has not been modified or updated for 7 years, but has the potential to be picked up in the future as it remains the property of an educational institution.

Outside of the five identified keys, the software used to produce heritage models and reconstructions is also significant to their potential longevity. Due to the length and depth of analysis required to form substantiated opinions of software in regards to sustainability, that conversation is conducted in an individual section.
CHAPTER FIVE

HERITAGE SOFTWARE AND SUSTAINABILITY

This chapter evaluates software used in heritage modeling over the past ten years, with particular focus on the most current, available software. Four software programs have been selected for their wide use and capabilities when used in heritage modeling on a city-wide scale. The four programs will be analyzed and compared in five categories to establish; user-friendliness, adaptability, proficiency, ease of access, and visual clarity. Although the scope of this study will be centered around establishing the sustainability of the software in question, it will also provide an overview of the general features heritage professionals should consider in their software selections.

Out of the plethora of modeling platforms and software available to the modern heritage professional, the four selected for this study were SketchUp, Revit, Rhino, and Autodesk’s 3dsMax. The selection of each was due to either their common application in many heritage models, or potential to be used in heritage modeling. Other programs continue to emerge and can be accessed at the top end of the professional scale of heritage modeling, particularly by those with architectural backgrounds. However, the four selected have a proven track record in both architecture and heritage, offering unquestionable potential to remain players in this market for the foreseeable future. Precedent for the selection of these four software
programs can also be illustrated in their use in various existing heritage models.\textsuperscript{69} It is also important to note this will not be a case study of a trial period of use on each of the selected software programs, rather an analysis of a variety of their components supported by user reviews and objective, measurable information obtained from the software providers websites and programs.

Finally, there is an added value in this analysis due to the fact that there are few points of reference in regards to which software to use when constructing a heritage model.\textsuperscript{70} Study of software is generally left out of academic works surrounding heritage as software is so changeable and often regarded as temporary. Architecture has historically had the most use for producing three dimensional models, and thus offer the most guidance as to what software has what application. Combining an understanding of the requirements of heritage modeling with information included from architectural resources will create a useful juxtaposition of software programs for anyone interested in creating a useful and sustainable heritage model.

\textsuperscript{69} Although it is often the case that heritage model constructors do not divulge their chosen software publicly, many instances can be found where it is included for the purposes of transparency. This is the case for many of the heritage models discussed in this thesis, for instance with the noted use of SketchUp for the construction of much of Virtual Williamsburg as well as the University of Reading’s Virtual Rome.

\textsuperscript{70} There are cases where software is compared and used in case studies, however this is more prevalent in the case of digital documentation rather than three-dimensional heritage modeling. Amanda Brown, "City Scaled Digital Documentation: A Comparative Analysis of Digital Documentation Technologies for Recording Architectural Heritage." Clemson University and the College of Charleston, 2016.
SketchUp – Trimble Inc.

SketchUp was released in August 2000 by a small start-up company located in Colorado, as a general purpose 3-dimensional modeling program. Six years later the company was purchased by Google to aid in their efforts to develop and create Google Maps and Google Earth.71 The most appealing aspect of the software has been, and continues to be, the fact that it is completely free to anyone who wishes to download it.72 Moreover, it is known to be particularly user-friendly and easy to learn in a relatively short space of time, which is key to how it has become a significant resource to those interested in modeling heritage. Many historians, archaeologists, city planners, and architectural historians have been able to turn to SketchUp to produce resources they may have previously believed to be beyond their own capabilities. Having continually been used and updated for 18 years, SketchUp has cemented its place as a staple of three-dimensional modeling. It has since been purchased in 2012 by Trimble Inc as Google no longer had a significant need for it but the software has remained free, with a “Pro” version available at an annual cost.73

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Revit – Autodesk

Revit is primarily a building information modeling (BMI) software for architects and engineers. Similarly to SketchUp, it was released in 2000 and was bought out by a larger company, in this case Autodesk in 2002. Revit is popular in the architecture community due to its ability to produce three-dimensional models, which can facilitate a lot of coordination that would historically be done in two-dimensional modeling software. BMI has begun to stem over into the heritage sector as such models could prove incredibly useful in the running and care of historic properties. This has become such a significant trend that the phrase HBIM has been created to represent the whole field of BMI modeling dedicated to the construction of historic models. A popular feature of the software is that it is “bi-directional,” which is a computer science term for if one part of a model is updated, the same part is updated on the model across all formats. Unbeknown to many, this is where the name Revit comes from as it is an amalgamation of the words “revise it.” By all accounts Revit is a difficult software to learn and become accustomed to, often taking years of use in an architectural setting to reach full competency. Its ability to offer

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multiple purposes and functions for models is an appealing prospect to modeling within heritage, especially in regards to sustainability.

**Rhino – McNeel North America**

Rhino (Rhinoceros 3D) is a computer aided design application used by an array of fields for creating both large and small scale digital renderings and models.\(^{78}\) It has been part of the McNeel & Associates umbrella since its creation in the 1990’s, although it was originally named “Sculptura,” until copyright issues deemed this name untenable.\(^{79}\) Rhino bases its geometry formulas heavily in mathematics, allowing them to create precise representations of curves and complicated shapes, leading to its use across many commercial fields such as product and car design as well as architecture. This more free flowing, design orientated programming offers an alternative method to modeling compared to Revit’s more practical, buildings information based approach. Rhino offers ample opportunities to the heritage sector in regards to reproducing historical sites or cityscapes if one is committed to learning the software over an extended period of time. It’s use to produce small scale commercial designs has made it particularly accommodating to 3d-printing which


could prove useful for heritage models with the ambition of being printed for use in a museum.\textsuperscript{80}

\textbf{3DS Max – \textit{Autodesk}}

Autodesk’s 3DS Max is a professional grade 3-D modeling system that is based more closely around quality of graphics and 3D animation rather than static, interactive models seen in the other three software programs.\textsuperscript{81} It was one of the first real programs created by Autodesk and has undergone several iterations since its inception in the late twentieth century.\textsuperscript{82} The proven track record for the software over multiple decades of use, both professionally and privately, is a very appealing trait to anyone looking to use a software that will remain relevant and capable when modeling. Its use in fields such as video game development and TV studios is a testament to the quality of animations it can produce.\textsuperscript{83} Reaching this “Hollywood” level of graphics is certainly an appealing ambition for a heritage modeler to have, but the skill set to use this software to that level is far more demanding than that of the likes of SketchUp. The monopoly Autodesk has on these types of architectural software across the board is an important fact to be aware of when selecting a

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{80} “Features, Rhino Website,” Robert McNeel & Associates, accessed December 2017.
https://www.rhino3d.com/6/features
\item \textsuperscript{81} “3DS Max,” Autodesk, accessed December 2018. https://www.autodesk.com/products/3ds-max/features
\item \textsuperscript{82} “3DS Max 2018 vs previous versions,” Autodesk, accessed December 2018.
https://www.autodesk.com/products/3ds-max/compare
\item \textsuperscript{83} “Autodesk for Games,” Autodesk, accessed December 2018.
https://www.autodesk.com/campaigns/autodesk-for-games
\end{itemize}
\end{footnotesize}
software. This allows users of Revit, AutoCad, 3ds Max, Maya, and a myriad of other programs developed and owned by Autodesk to be interchangeable and effective when used in concert together.

Software Comparison

Comparing these four software programs to gain an insight into their uses and potential sustainability is the most useful way to help establish their strengths and weaknesses for someone interested in using one of them in the heritage sector. Projects in heritage can range from archaeologists modeling artifacts, house museum curators building BIM models for property management, or an architectural historian recreating a historic cityscape, each program has specific functions that could be best suited to a specific requirement.

Due to the significant amount of time it takes to individually run a case study on each program to identify factors such as user friendliness or visual quality of images they produce, a number of online reviews will be utilized to form the basis of this assessment. Although subjective, online reviews such as these do not usually come with a great deal of integrity when used in an academic environment, when enough are considered from an appropriate and reputable site the information carries considerable weight.84 User reviews given by industry professionals also

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have less of a chance of being emotionally motivated, and more of a chance of being a
genuinely reflection of their experience with the software. Moreover, a large portion
of information has been accessed from the program or program supplier's website
where it is readily and transparently viewable and accessed.
<table>
<thead>
<tr>
<th></th>
<th>SketchUp</th>
<th>Revit</th>
<th>Rhino</th>
<th>3ds Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years since inception</strong></td>
<td>18+</td>
<td>18+</td>
<td>24+</td>
<td>25+</td>
</tr>
<tr>
<td><strong>Cost to use - 2018</strong>*</td>
<td>Free* (Pro version available for $695 a year)</td>
<td>$2,200 a year</td>
<td>$995 for permanent use, $495 to upgrade old version* (prices for windows)</td>
<td>$1,470 a year</td>
</tr>
<tr>
<td><strong>General features/capabilities</strong>*</td>
<td>Documentation rendering, reconstruction, simulation</td>
<td>Documentation rendering, reconstruction, simulation, bidirectional, programmed to represent building systems information</td>
<td>Documentation rendering, reconstruction, simulation, large or small creations, accurate, BIM compatible</td>
<td>Documentation rendering, reconstruction, simulation, animation, easily integrated with other Autodesk platforms</td>
</tr>
<tr>
<td><strong>User-friendliness</strong>*</td>
<td>High</td>
<td>Moderate - High</td>
<td>Low - Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Visual quality</strong></td>
<td>Moderate</td>
<td>Good</td>
<td>Good</td>
<td>High</td>
</tr>
<tr>
<td><strong>Platforms</strong></td>
<td>Windows &amp; Mac</td>
<td>Windows* (Can run on OS with assistance of other programs)</td>
<td>Windows &amp; Mac</td>
<td>Windows* (Can run on OS with assistance of other programs)</td>
</tr>
<tr>
<td><strong>Compatible with .dwg file (AutoCad)</strong></td>
<td>No* (SketchUp Pro is)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>3d printing compatible</strong></td>
<td>Yes* (Plug in required)</td>
<td>Yes* (Plug in required)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Table 5.0 – Comparative table juxtaposing the capabilities of SketchUp, Revit, Rhino, and 3DS Max*

This table serves as a reference point for anyone interested in the capabilities of software in regards to building a 3D heritage model. All information represented is accurate as of February 2018.
The information represented in *Table 5.0* is a basic comparison of measurable features of the four software programs selected, particularly focused around what may appeal to heritage professionals. Each program has a great number of other qualities and features that are not represented in the table, but this overview allows for a general comparison to inform interested parties as to which software would be most appropriate for their specific project. User-friendliness and visual qualities have been assessed from user-reviews found at reputable and professionally recognized sites, and have been measured on a “Low, Moderate, Good, and High” scale. Visual quality is judged in regards to whether the quality of model represented is up to today's standards in graphics. A “Moderate” or higher ranking in this category means that the graphics are of an acceptable standard for 2018: the images produced are clear and realistic, the textures and surfaces are represented accurately and without distortion, and there is a clear advancement in quality compared to the final product of previous iterations of the software.

The first feature of all four software programs that stands out is the fact that they have all been in existence for a significant period of time. This is an important factor in regards to the sustainability of each of the programs as they have all established themselves as mainstays in the world of 3-dimensional modeling, and show no signs of letting up. Their ambitions to remain at the forefront of relevance in this field is also represented by the fact they have all adopted new technologies over their life spans. Each program has made allowances to be compatible with 3D printing, and all have the ability to run on the two major platforms of the 21's century,
Windows and Mac.\textsuperscript{85} This is further supported by the \textit{Figure 5.1}, which represents the amount of versions that have been produced of each software since 1995.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{number_of_versions_since_1995.png}
\caption{Line Graph depicting the number of versions/ iterations of each software. \textit{Figure 4.9} – Bar chart representing the estimated life spans of the analyzed models.}
\end{figure}

Revit is only represented from 2000 onwards as they were purchased by Autodesk in 2002. Having been released under numerous umbrella releases, Revit was released individually year by year from 2013 onwards. SketchUp is represented from its purchase by Google in 2006 and only includes its free version. However, since its acquisition in 2012 from Trimble, both SketchUp free and SketchUp pro have been released yearly. There have been numerous upgrades and changes to each software more regularly that are not included in this graph.\textsuperscript{86}

\textsuperscript{85} SketchUp and Rhino have both created versions of their software for complete and unrestricted use on Mac, Revit and 3DS Max do not currently offer the same service but they allow for other software companies to produce platforms to run their services on Mac. For example, Autodesk have certified a platform named "Frame" to allow for the use of their products on Apple Mac products. Damien Jovica. "Finally. Autodesk Revit for Mac." \textit{Redstack} (blog), Fall 2015. Accessed December 2017. https://redstack.com.au/support/blog_posts/finally--autodesk-revit-for-mac.

\textsuperscript{86} Information regarding the histories of these software's is hard to find and can be incredibly convoluted due to the rate of change within technology companies. The information represented in the graph is an amalgamation of a number of sources but is an effective representation of the amount of change that has occurred within each respective software. The most fruitful source of information pertaining the software development is the software manufactures websites.
This constant updating to the software has grown more regular over time, with the majority of the programs now releasing yearly updates. *Rhino* is unique in this regard as they have released versions of their software periodically since 1995, and are currently on their sixth version in just over 20 years. Naturally, the two software programs under the maintenance and ownership of Autodesk have both received a similar treatment of yearly updates. The gap in the amount of versions between the Autodesk products and the two others isn’t very significant in regards to sustainability, as their place in the 3-D modeling market is counterbalanced by a number of factors. The fact that *SketchUp* is available for free is a hugely important factor in the software’s ability to remain relevant and useful, as it introduces the ability to create models to whole new audiences, including in the heritage sector. Similarly, *Rhino* offers a draw from those considering the Autodesk products in the form of a onetime payment for use of their software for life, with discounted rates on future updates. All four programs appeal to audiences from varying backgrounds for different reasons. They all diversify the market in a way that they all have a place and all can continue to develop and remain relevant moving forward.

In addition, these programs monopoly over modeling is also cemented by the fact that other companies build their software around being compatible with these programs. Many VR and AR firms that are currently producing software are building
their programs around these four platforms, which is a trend likely to continue. The malleability of the capabilities of these software platforms is also represented by the fact that it is increasingly easy to interchange models between platforms, as detailed by a number of methods online. Much like Microsoft Word being available on Apple Mac products, Autodesk’s AutoCad files (often the industry standard for documenting 2D models of heritage sites) are compatible with all four software programs discussed.

Although none of these programs were purpose built for use in the heritage sector, or even built with them in mind, combined they can serve any need of a heritage professional in producing a digital historic resource if they so desire.

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87 A wide of software available to users of Revit, SketchUp, Rhino, and 3DS Max to utilize post construction. This is a topic addressed in further detail in chapter six phase 6 of this thesis. Some of the software programs that are particularly worth noting however are: Unity, Navisworks, and Kubity.

88 Numerous blog posts, YouTube videos, and online discussion forums detail a variety of methods to achieve this. Each of the four software programs studied has a helpdesk article in reference to converting other types of modeling files. For example: “Import SketchUp Files,” Autodesk.Help, accessed December 2017. https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Revit-Model/files/GUID-57805933-917B-4B5B-9AD2-80396354EDE0-htm.html

89 There are caveats associated with fulfilling this on the two software programs that are not produced by Autodesk. The process of importing a .DWG file into Sketch Up is addressed in Chapter Six of this thesis, importing a .DWG file to Rhino is addressed by numerous forums online. For instance: “Why Does My DWG Not Open,” McNeel Wiki, accessed December 2017. https://wiki.mcneel.com/rhino/dwemptyinrhino
The second part of this thesis is dedicated to the construction of a digital heritage model. Each element of construction is broken up and represented in its own independent phase, with each phase then broken up into an *overview* and *implementation* section. Employing the *overview* section alongside that of the practical implementation of each phase allows for overarching guidance to be offered to heritage professionals interested in creating their own digital reconstruction. The six phases that constitute the crafting of a sustainable digital heritage model are: topic selection, software and format selection, research, model underlay creation, model construction, and post completion.

Included at the end of the model construction phase is a designated subsection committed to tackling methods of visually representing missing information or ambiguity within heritage models.

**Phase 1 – Topic Selection**

*Overview*

The first order of business in building a heritage model is to establish what you want to build a model of. Whether it is Ancient Rome, Medieval London, or Antebellum Charleston, the area of focus needs to be clearly identified on multiple
fronts. Is it a model of one particular year in a city’s history? Is it representing a significant historical figure? Is it covering an entire city or just a neighborhood?

The most important question that needs to be tackled from the outset of this process is that of why? What is the purpose of this model? Is it for solely educational purposes? Is it an experiment of the latest technologies and software available to heritage professionals? Is it to produce a 3D printed model for exhibition in a museum? Or is it all of these things? These are questions that need to be answered from the outset of model construction to shape the whole direction and process of the project.

In addition, the larger the scale of the project the more that goes into its construction. A city-wide reconstruction of a historic city-scape is often a multi-year venture that requires the input of numerous professionals. Much like a book or written piece of academia that requires readers and editors outside of the individual or group that produced the work, heritage models on this scale require similar attention. Working in a team is although not fundamentally required, highly recommended.

**Implementation**

This model will be of 1822 Charleston, South Carolina, and will serve as a digital depiction of the life of Denmark Vesey. The scope of the model will be city-wide, with particular focus to sites significant to telling the story of Denmark Vesey. This model’s purpose is to serve as an educational resource and alternative medium
of interpretation, interaction, and engagement in Denmark Vesey as a historical figure. The need for this model is further represented by the fact that finding ways to connect with and engage with the life of Denmark Vesey has always been a sticking point within Charleston. A number of efforts have been made to memorialize him throughout the city over the past thirty years and each has been met with a degree of contention. The clearest example of an effort to memorialize Vesey on a national level was the recognition by the National Register of Historic Places of a property at 56 Bull Street as the official “Denmark Vesey House.” The search for a place to both memorialize Vesey and engage the public with his life was launched by the Afro-American Bicentennial Corporation in the 1970s, as they realized the potential such a place would have going into the future. Having identified the property on Bull Street, they presumed they had succeeded in establishing a permanent location to memorialize and engage in Denmark Vesey's life. However, this success was short lived, as the building has since been proven to have not even existed during Vesey's life, most likely being constructed in the 1830’s. Today, there are incredibly few mediums of interpretation and engagement left to introduce the public to an

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unquestionably significant figure in American History. This model will fill this hole in the field of Denmark Vesey, and become a resource for the public engagement about his life in Charleston in an immersive and interactive format.

This model will be built to be a sustainable digital resource that will maintain its function for an indefinite period of time. This will be achieved through the implementation of the keys to sustainability identified in the previous part of this thesis, revolving around high quality information and the use of adaptable, progressive software.

The scope of model construction will focus around completing two sites significant to Denmark Vesey during his life time. This sample is large enough to convey to methodology of creating a heritage model on a professional scale, as well as providing the beginnings for a much larger project in the future.

**Phase 2 – Software and Format Selection**

*Overview*

The requirements for the desired project need to be measured against the capabilities of existing software, as well as what software is realistic to obtain, learn, and use. Options for this decision are varied and often overwhelming. Heritage is not

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95 The justification for which sites that are represented by this digital model is addressed Phase 3a of this chapter.
a field that modeling software is purpose built for, and the high price of many software programs reflect the demand for them in areas such as architecture, engineering, and construction.

This decision again relates to the ultimate purpose of the model. Is it something that will be accessible online? In video format? In physical format? Is it something that will be created by multiple individuals with varying backgrounds and experience in heritage and technology? All of these factors need to be considered and evaluated against available software.

As discussed in Part 1 of this thesis, SketchUp (Free and Pro), Revit, Rhino, and 3DS Max are four proven software programs with far reaching capabilities in the heritage sector. These are four worthwhile first stops for anyone modeling in heritage as they cater to almost any requirement conceivable, with a proven track record of adapting to current technological climates. However, if these four platforms are lacking in certain areas desired by heritage professionals, there are a myriad of other options available. Studying precedent and existing models similar to the desired format and purpose of the proposed model is highly recommended.

**Implementation**

SketchUp Pro is the software being utilized for the Denmark Vesey model of 1822 Charleston. Although all four software programs discussed are available as a graduate student through Clemson University, SketchUp’s format, abilities, and
potential made it a clear choice. Had the “pro” version not been available, the same decision would have still been reached as the fact that it is free and easily accessible is a significant factor in the software’s sustainability moving forward. Moreover, the future completion of this model is currently unclear, meaning that the less obstacles to its completion and maintenance the better. SketchUp offers by far the least amount of barriers to the models completion, as it could be picked up and continued by anyone involved with heritage with little to no background in technology. SketchUp also offers a significant amount of options for plug-ins to allow models to interact with the latest available software such as 3D-printing and virtual and augmented reality.

This decision is further supported by comparing the requirements and goals of this model to past models produced in heritage. One of the most alike models created in the past ten years in both its scope and ambition, is that of the reconstruction of 1853 Richmond, Virginia to represent the city’s spatial relationship with the slave trade. This model was produced by a team of academics from various backgrounds and professions, but specifically by the Digital Scholarship Lab who develop digital humanities projects in conjunction with the University of Richmond. Although employing multiple software platforms, including esri CityEngine and Autodesk’s 3DS max, the majority of model was completed using SketchUp.96

The format and means of accessibility to the model are in keeping the ambitions of the Charleston model for numerous reasons. The Richmond Slave Market model represents 1853 Richmond on a city-wide scale, with specific focus to an area of significance, in this case the Slave Market. This will be the format employed by the Charleston model, which will represent the city of Antebellum Charleston with areas of significance representing the life of Denmark Vesey.

Moreover, the decision to use an underlay to provide the foundation for building the model is a choice that will be replicated with the construction of the Charleston model. This not only allows for a more accurate reconstruction, but also a definitive end to the models area. If a map is not available from the time period in
question for the proposed model, then research needs to be conducted from numerous sources in and around the period in question to create one. The research and ultimate creation of this underlay is addressed in a later phase.

The 1853 Richmond model also utilizes the use of an incredibly informative and clear video as the main form of interaction to the model. This is definitely a medium that should be produced for the 1822 Charleston model, but a higher level of interaction using the latest technologies should also be the ambition. A precedent for this is represented in the previously analyzed Virtual Rome model produced by the University of Reading and Dr. Matthew Nicholls.97 Virtual Rome uses a software named Kubity, which has a free and paid version, and offers models created in SketchUp or Revit the opportunity to become compatible with both Virtual and Augmented Reality.98 Kubity will be used for the 1822 reconstruction of Charleston to perform this exact function, giving the model the best chance moving forward to be sustainable through its multiple forms of engagement.

Ultimately making the model freely accessible online, and with its own website and contextual information is the end goal for this project.

98 Kubity was designed to be compatible with both SketchUp and Revit, and is available as a free download to be installed as a plugin for direct transfer from model space to their interactive platforms. “Kubity,” Speak 3D, accessed January 2018. https://www.kubity.com/
Phase 3 – Research

Overview

As identified in Part One, quality of scholarship is integral to the longevity of a digital heritage model. The scale of research required for city-wide digital reconstructions should be as intimidating as it sounds. To tackle this, research should be broken down into typologies such as map research or architectural research to make it more manageable. The multitude of historic resources now available to heritage professionals should be scoured and utilized as often and as thoroughly as possible. This is a process that should continue onwards throughout the rest of model construction and beyond.

There are times when decisions need to be made to limit or draw a line in research as not every architectural feature of a building or place was recorded, drawn, or documented, and sometimes information just doesn’t exist. However, missing information should not be taken as a free pass for modelers to blindly guess at what historic landscapes or buildings may have looked like according to their own imagination. Heritage professionals should draw on their background and contextual knowledge to create a realistic version of what could have existed at that time and place, utilizing the opinions of other experts when possible. Identifying methods of visually representing these areas should be explored and employed.\footnote{Methods to visually represent cases such as this are explored in Phase 5 of this chapter.} These areas should also be represented in post-production to draw attention to areas that could
benefit from further research in the hopes of inspiring others to engage in their own academic endeavors.

**Implementation**

The implementation section of Phase 3 is broken up into an ‘a’ and ‘b’ section. Phase 3a includes background research necessary to give the model creator the required level of academic authority to represent a useful and accurate model of Denmark Vesey and 1822 Charleston. This phase relies on the use of secondary sources as the life of Denmark Vesey is already an extensively documented part of American history. This research culminates in the identification and academic exploration of areas within the City of Charleston that were significant to Vesey’s life, which will serve as the focal point for the model.

Phase 3b will focus more specifically on Charleston and the layout of the city in 1822. This research will allow for the creation of a map of the city to serve as the underlay for the model. Where were the boundaries of Charleston in 1822? What did the road system look like? How were the house numbers different? Where are the buildings still standing today that can help anchor this map? The site of each area of significance will then be placed into this map in as accurate of a location as possible, and the construction of the model can then commence.

The research involving the rest of the city will continue as the project develops. This includes factors such as what the roads, parks, and landscape would have
visually looked like. Any incomplete research will be detailed and incorporated into a plan at the conclusion of this thesis.

**Phase 3a – Denmark Vesey and Site Identification**

Denmark Vesey is a heavily studied and researched historical figure, particularly over the course of the past thirty years. Although a clear understanding of Vesey’s life is a significant requirement to constructing a digital resources representing his life, there is no need for this project to spend a substantial amount of time repeating work conducted by countless other historians. Leaning on prominent biographies, a comprehensive and well informed understanding of Denmark Vesey can be readily established.

Two biographies stand out as being particularly useful at detailing Vesey’s life. *He Shall Go Out Free: The Lives of Denmark Vesey*, by Douglas R. Egerton is one of the more recent accounts, which in the convoluted historiography of Denmark Vesey marks it as one of the most reliable. While *Denmark Vesey’s Revolt: The Slave Plot that Lit a Fuse to Fort Sumter* by John Lofton is arguably just as useful, having endured multiple edits throughout the second half of the twentieth century. Both accounts briefly describe the early, undocumented life of a young Denmark Vesey from his birth (on St. Thomas) up through to this trial and execution.100

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Figure 6.2 – Timeline of Denmark Vesey’s life.
This timeline was based on two Vesey biographies – He Shall Go Out Free by Douglas R. Egerton, and The Slave Plot that Lit a Fuse to Fort Sumter by John Lofton.

Timeline by author
The next phase of research involves identifying key sites to serve as the focal point of interaction within the model. Numerous sites emerge across both the primary and secondary sources, but the list needs to be whittled down to a manageable amount before construction can begin.

Certain locations appear consistently throughout biographical and primary sources. A case could be made for where he lived, worked, worshipped and died being central components for the map, as these sites are representative of his life as a whole, and are readily identified throughout many of the sources. Specifically speaking, his house is designated as being a rental property on Bull Street where he both lived and worked. Vesey worshipped at multiple churches during his life in Charleston, he is noted for attending the Second Presbyterian Church on Meeting Street before playing a role in the establishment of an AME church in Hampstead. His trial and that of many of his co-conspirators was held at a place called the “Workhouse” on Magazine Street, although the gallows were built in an area known as “Blake’s Lands” in the neck.101

Moreover, should the three-dimensional representation of Vesey’s life be restricted solely to the places he physically had interaction with? Or does it go beyond that? City Census records from the first half of the nineteenth century consistently illustrate that the enslaved population greatly outnumbered that of their Euro-American masters in Charleston.102 In fact, the majority of sources written about Vesey cite this as a significant factor in the highly charged tensions within Charleston

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102 This is a point touched on in many academic works surrounding Vesey, including both Egerton and Lofton’s biographies.
that set the stage for the alleged uprising. Does this merit sites such as Gadsden’s Wharf, a main point of arrival for countless slaves into Charleston and America, a place on the list for sites that tell the Denmark Vesey story? Furthermore, should sites that would have been in the intended plot be included? The city arsenal and guard stations were described at length in the trial records and biographies to be the identified targets of the planned attack.103

Ultimately, the decisions as to which sites to include relates to the original purpose of the model. This model is being constructed to serve as an educational resource to engage the public in the life of Denmark Vesey. In order to best represent the life of Denmark Vesey sequentially, an array of sites throughout his life here in Charleston need to be included. There is certainly space for this model to grow and develop into other areas in the future. For instance, highlighting how the uprising itself would have theoretically played out across the city, or the employment of visual layers to illustrate statistics that would help represent population densities from census records. But the initial priorities of the model lie with representing where in the city Denmark Vesey lived and evolved into the man he became.

103 This is discussed on multiple occasions during the trial, as represented in the trial records. John Oliver Killens, ed. The Trial Record of Denmark Vesey: The Slave Conspiracy of 1822 (Englewood Cliffs: Prentice Hall, Inc., 1970)
List of Potential Sites that Represent Denmark Vesey's Life in Charleston:

1) Denmark Vesey House – Bull Street
2) Workhouse/Trial Site – Magazine Street
3) Second Presbyterian Church - Meeting Street
4) AME Church – Hampstead

To be included in this list a site had to possess a documented association with Denmark Vesey by historical accounts and existing research. It would not be enough to argue for reconstruction of King Street because Vesey probably walked down it as a resident of Charleston. The association has to represent a significant period, moment, or theme in Vesey's life. For instance, spirituality is a common theme across literature and source information about Vesey. Thus any association he was recorded as having with a church is significant and those places were consequently considered for inclusion. Similarly, Vesey’s house on Bull Street and the Workhouse where his trial took place are both represented in primary sources and are included in the list above.

The two sites selected for digital reconstruction during this thesis are Denmark Vesey's house, located on Bull Street, and the Second Presbyterian Church on Meeting Street. These two have been selected for the significant roles they played in Vesey's life over the twenty plus years he spent in Charleston, but also because they offer two different examples of scenarios that occur within digital historic reconstructions. The building designated as The Denmark Vesey House that is on the
national register is shrouded in doubt and uncertainty, both stylistically and geographically. This situation allows this thesis to represent methods of illustrating this uncertainty visually within heritage models. In juxtaposition, the Second Presbyterian Church on Meeting Street is in the same location as it was in 1822, with only minor alterations to the exterior having occurred. The two examples will combine to allow this thesis to offer further guidance to heritage modeling, outside of its primary contribution to the discussion surrounding sustainability and digital modeling.

*Denmark Vesey House – Bull Street*

As a free man in Charleston between 1800 and 1822, it is widely believed Denmark Vesey spent life as a carpenter in and around his home on Bull Street.\(^{104}\) The *1822 Charleston Directory and Strangers Guide* lists Denmark Vesey at an address on “20 Bull Street,” and is his only appearance in such a document.\(^{105}\) Not only is this house significant for being Vesey’s primary residence in Charleston (despite never owning it, only renting it), but it has a greater significance in regards to the formation of the rebellion itself. It is here that the trial records and consequently many historians allege that Vesey would host Bible study classes where he recruited many

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\(^{105}\) 1822 Charleston City Directory, accessed at South Carolina Room, Charleston County Public Library.
followers as well as held meetings involving the plots leadership. A property is currently listed on the National Register as the “Denmark Vesey House,” but has since been recognized by scholars and the National Park Service as most likely not being Vesey’s original residence. Elias Ball Bull, who was responsible for linking the property to Vesey during the nomination process, is supported by other biographical sources who agree that Vesey lived somewhere within the vicinity of modern 20 Bull Street.

Figure 6.3 – The” Denmark Vesey House” – 56 Bull Street
Since being designated on the National Register of Historic Places, the building has been widely accepted to have been constructed in the 1830’s a decade after the death of Denmark Vesey.  
Photo by author

106 John Oliver Killens, ed. The Trial Record of Denmark Vesey: The Slave Conspiracy of 1822, 45.
Reconstructing a building when no source information is available to guide or inform what is visually created is a difficult task. A confluence of research and educated conjecture needs to occur to create a product that is as accurate and academically responsible as possible. Geographically, from the 1822 City Directory we have a street address to work from when trying to place the building on a map. It is clear however that this address, as many others in Charleston, has shifted over the 200 years.\textsuperscript{108} Although resulting with the highly contentious National Register listing, Elias Ball Bull undoubtedly still produced useful research for scholars of Vesey. Of particular use was his identification of who lived where on Bull Street in 1822 through extensive chain of title research, the results of which are represented below in the map he produced to accompany the nomination.

Figure 6.4 – Bull Street in 1822 according to Elias Ball Bull.

Bull went to great lengths to identify each resident in the vicinity of the property believed to have been lived in by Denmark Vesey.

Map courtesy of National Register Nomination for the Denmark Vesey House, 1976.
The methodology behind the production of this map is certainly logical. The current listing of 56 Bull Street is overridden by Bull’s identification of surrounding owners who match up with the 1822 City Directory. This supports his assigned numbering system from the start of Bull Street westward. However, this location has been called into question by archivist Wylma Waters and architectural restoration consultant Edward F. Turberg, who in their rebuttal to the property’s listing as a whole, suggest that the site was more likely four or five houses east of the current location.\footnote{Egerton, \textit{He Shall Go Out Free: The Lives of Denmark Vesey}, 83.} Considering all points and available information, representing the Denmark Vesey house within the block between Pitt and Smith streets is the limit to the amount of accuracy that can be placed on the exact location.

The most detrimental problems that have been identified with the nomination since it was accepted are focused around the uncertainty around the building on the plot today. Some significant materialistic and stylistic factors do not add up, suggesting that it was most likely not constructed until the 1830’s.\footnote{Felzer, \textit{The Charleston Freedman’s Cottage: An Architectural Tradition}, 29.} As seen in \textit{Figure 6.5}, Bull acknowledges that the property on the plot today has been altered since its construction, but still posits that both the material and style matches that of a house from Vesey’s lifetime.
The assumption that Vesey’s rental property would have consisted of a kitchen, dining room, and living room heated by a central fireplace is understandable. The style of the house could also be construed to match that of which someone of his social standing would have lived in during the early 19th century. In fact, the layout is consistent with a type of property that has since become known as a “freedman’s
cottage;” a small, single story, timber framed house with a gabled roof and piazza. A source of great use in the area was written by Lissa Felzer in 2008 named *The Charleston Freedman’s Cottage, An Architectural Tradition*. Felzer discusses the origins and known definitions of these types of property in Charleston at length, paying significant detail to their basic make-up and functional floor plans. She primarily argues that the term “freedman's cottage” relates more to a buildings “typology as opposed to who lived there or built it.” It is often misconstrued that this is a building type that emerged after the civil war, when they actually occurred prior to this in vernacular forms across the south. Ironically, Felzer argues that one of the earliest examples of this building typology in the city is the Denmark Vesey House that is listed on the National Register, suggesting that they do not emerge as a prominent house form until well into the second half of the 19th century. Thus, the earlier forms of “freedman's cottages,” according to Felzer, were early interpretations of the Charleston single house. Considering this, the property that Vesey occupied at “20 Bull Street” in 1822 would have most likely been a single story version of the Charleston single house, orientated gable end towards the street, with a central fireplace. It would have been timber frame with weatherboard siding, three bays across facing the street with one of the bays being the piazza/porch which may or may not have been screened (most likely not, added expense).

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111 Felzer, *The Charleston Freedman’s Cottage: An Architectural Tradition*  
With this aesthetic conclusion in mind, other known pieces of information can confirm what we have established as the most likely appearance of the house. We know from various sources that Vesey used the house as a workshop for his carpentry business, as well as a meeting place for bible study. This would have meant that the property would have needed to be multi-functional. We know despite buying his freedom, he lived an incredibly challenging financial life as much of the trade work in Charleston would have been performed in-house by slaves. This would have juristically undercut tradesman such as Vesey whose services would have had to outweigh those of the enslaved to merit their hiring. We know that the property was owned by at least two men that we know of; a local attorney named George Cross, and later a carpenter named Benjamin Ireland.114 Both men would not have leased out an expensive, high style fashioned house to a free person of color. All things considered, it is fair to surmise that the property would have been small, robust, and multi-functional. There likely would not have been much money dedicated to its construction or upkeep, offering cause to suggest that it would have been built with the most readily available and affordable materials.

The reality of digital historic reconstructions is that there will be missing information. Sometimes conclusions need to be reached that are insubstantial to the standards often expected in historic scholarship. To maintain credibility and integrity

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when faced with obstacles such as these, the model builder needs to be as transparent as possible with why what is represented in the model is constructed the way it is.

Second Presbyterian Church – 342 Meeting Street

The Second Presbyterian Church, located on 342 Meeting Street, is one of two churches that it is certain Vesey attended for a certain period of time. Prior to the establishment of the first AME church on the Charleston peninsular, Vesey is known to have attended the Second Presbyterian Church on Meeting Street due to being listed as attending a service in 1817 under the name “Danmark Vesey”. Egerton also suggests in his biography *He Shall Go Out Free* that it isn’t out of the question that Vesey married his final wife, Susan, there at some point between the churches completion in 1811 and the formation of the AME church in 1818, although this is purely a theory. It is most likely that Vesey was introduced to the congregation by his former master Joseph Vesey around 1817, but due to the fact that when Vesey is recorded as being in attendance he was the only one of the “three people of color” there not to be baptized, this was probably not his first experience with the church. Although the church was not as significant a place in the scope of Vesey’s life compared to the AME church, it is one of the few remaining structures in Charleston

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where there is direct proof that Vesey ever visited or had interaction with, however brief.

The church retains its original form. It has endured many natural and man-made disasters over the past two centuries, suffering varying degrees of damage, usually resulting in the direct replacement or refurbishment of the damaged areas.119

![Second Presbyterian Church](image)

**Figure 6.6 – Second Presbyterian Church (originally The Second Presbyterian Church of Charleston and its Suburbs), 342 Meeting Street, Charleston SC**

The church looks much today as it did in 1822. Built between 1809 and 1811, it is the fourth oldest church in Charleston.  
*Photo by author*

Stylistically the church certainly fits its period of construction. Having been completed in 1811, the church includes elements of federal architecture as well as

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119 There are multiple sources that document the damage that occurred to the Second Presbyterian Church over its life-time. The building vertical file available in Charleston County Public Library and the Church’s website are both good starting points. “Our Living History,” Second Presbyterian Church, accessed March 2018. http://www.2ndpc.org/our-living-history/. Vertical File, 342 Meeting Street Second Presbyterian Church, accessed at South Carolina Room, Charleston County Public Library.
elements of the newer classical revival style that was emerging during this period.\textsuperscript{120} The fanlight visible above the door and in the pediment above are qualities visible in many federal period buildings throughout Charleston, and the two-story portico with Tuscan columns are in keeping with the classical revival that emerged from the early to mid-nineteenth century. Originally, it was intended to include a spire on top of its centrally located tower, but the failure to ultimately include it is generally credited to a lack of funds.\textsuperscript{121} A decision was made to include an octagonal belfry, which owing to the size of the building and its elevated topographical position, became utilized as a landmark and reference point.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{church_engraving}
\caption{Illustration taken from the 1875 Guide to Charleston: Illustrated, by Arthur Mazyck. As seen in this engraving from 1875, the church at 64 years old closely resembles its appearance today. Image courtesy of University of California Libraries, accessed from archive.org}
\end{figure}

Due to the buildings lack of any evident whole scale changes, there is an opportunity to represent a good degree of academic certainty within the model. Accurately anchoring the building in 1822 Charleston will rely more heavily on inserting it into the correct context. The church is situated on Wragg square, in the area still commonly known as Wraggborough on land that at the time sat on the periphery of the city. As seen in Figure 6.7 and Figure 6.8, the church is quite significantly recessed from Meeting Street street at its position on the east side of Wragg Square. The square gives the church a distinctly more rural feel, which is again in keeping with its original intended purpose of serving “Charleston and its Suburbs” on the edge of the original town. The square is also lined with numerous properties that were built to escape the original crowded nature of the city, such as the Joseph Manigault House the was completed in 1803, which currently serves as a house museum.122 There is also a cemetery adjacent to sanctuary with gravestones from as early as the Revolutionary War and the War of 1812.123

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A resource of particular note is an 1801 plat of Mazyck-Wraggborough, which pre-dates the construction of the church by ten years but effectively represents the layout of the surrounding area.\textsuperscript{124} Wragg Square is also represented in the plat, illustrating that the space had already been donated by the Wragg family for sole use as a public green space, which proved a significant factor in the congregation’s decision to build a church on one end of it ten years later.\textsuperscript{125} This plat will also be useful during the construction phase of this site, as it can be inserted into that area of the map underlay to aid in representing the context into which the church existed.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{wragg_square.jpg}
\caption{Picture of Wragg Square taken from the Portico of the Second Presbyterian Church.}
The square fronting Meeting Street has always been an integral feature of the church and neighborhood.
\textit{Photo by author}
\end{figure}

\textsuperscript{124} 1801 Plat of Mazyck-Wraggborough, accessed in South Carolina Room, Charleston County Public Library, Book. 1, Page.48, Plat 00549.
\textsuperscript{125} “Church Celebrates Anniversary.” \textit{The News & Courier}. April 2, 1984.
Wragg Square can be seen on the corner of Charlotte and Meeting Street as it is today. The clear open space that had a guarantee to remain in that condition was an attractive proposition for a congregation searching for a church site.

*Figure 6.9 – Plat of Mazyck-Wraggborough 1801 by Joseph Purcell*

*Plat accessed from the CCPL S.C. Room*
The digital reconstruction and representation of the Second Presbyterian Church will be an incredibly useful juxtaposition to the construction of Denmark Vesey's house. There is more than enough physical and academic information to accurately reconstruct the church as it would have looked in 1822, and continued research during the construction process will further cement this.

**Phase 3b – Map Research**

Establishing an accurate map to serve as an underlay for heritage models is vital when recreating historic cityscapes. Without the underlay to geographically tie the buildings together, the model will just consist of a collection of buildings with no sense or order to their existence within a model. Moreover, reconstructing a historic environment goes further than just the architecture. The roads, street layout, vegetation, and landscape all needs to be accounted for to create the immersive and engaging environment for those who interact with the model.

Charleston has been fairly well mapped out since its inception in the seventeenth century as a British colony. There are numerous maps that occur periodically detailing the layout of the city throughout time. These maps range from fire insurance maps created by the Sanborn Fire Insurance Company to account for existing property in case of fire, to plats drawn for legal use in wills and conveyances. In regards to the model in question to represent Denmark Vesey’s Charleston, there was no map created on or around 1822. This definitely causes issues pertaining to
accuracy, but is not an insurmountable problem and will mean more reliance being placed on alternative sources to create one.

There are a number of maps created in the nineteenth century that can be combined with research to create as accurate of an underlay as possible for the 1822 model. The first known map to include buildings on it is the Bridgens and Allen map created in 1852, thirty years after the date in question.\textsuperscript{126} Thirty years may seem like a relatively short period of time on the scale of things but is nowhere near accurate enough considering the rate of development during the first half of the nineteenth century, particularly in Charleston. There is another map created in the early 1840’s as a guide to the city, engraved by J.B. Nixon based out of 81 Meeting Street, that offers a useful legend with notable landmarks labelled.\textsuperscript{127} As seen in Figure 6.10, the inclusion of these landmarks makes it useful when tying it to a modern day map of the city.


\textsuperscript{127} “Plan of the City of Charleston, Charleston Neck, and its Vicinity with the latest improvements and alterations, designed as a Guide for the City,” J.B. Nixon, 1842, accessed at South Carolina Room, Charleston County Public Library.
In addition, using a map of 1804 Charleston to compare the changes in street layout and landscape would be an incredibly useful exercise to measure or identify any change that may have occurred. The map (Figure 6.11) was engraved for the "Patrons of J.J. Negrin’s Directorial Register & Almanac," and like the 1840’s map includes a legend of notable buildings and churches. Interestingly, it is not only the closest map available to the period in question for the model, but is one of the few existing maps of Charleston representative of the city’s layout during Vesey’s lifetime.

When comparing the two, it is noticeable that the boundary of Charleston city is on Boundary Street, which is modern day Calhoun Street. Everything north of this point was considered the neck during this period, and it is into this area that the city expands over the next half a century.

Moreover, there are numerous similarities existing along the coastline of the peninsular, with the sea wall included definitively at the southern tip of the peninsular. Rather ironically, the construction of this sea wall was tied to the course of Vesey’s life, as it was a lottery to raise funds for its construction that rewarded him with the winning ticket back in 1799. ¹²⁹ The jagged outcroppings of the port along the Cooper river shoreline is clear in both maps, and the street layout for the most part is identical in footprint.

Another useful side effect of the expansive amount of research conducted on Vesey’s life, is that many biographers found it prudent to compile a basic map of the city for illustrative purposes. Two that stand out for their eligibility and integrity are those by Douglas Egerton and Edward Pearson. Both maps were created in conjunction with their extensive research projects, and even more significantly they
were created within the past twenty years. The fact they were created at the end of the 20th century means that they have taken into the consideration more research and sources than earlier works, and both recognize the uncertainty behind Vesey’s designated house on the national register. Of the two, Pearson’s is arguably the most useful due to its professional and relatable format.

**Figure 6.12 – 1822 map of Charleston by Edward Pearson**
Arguably the clearest map of 1822 Charleston created, Pearson’s map offers a very useful insight into the city’s layout in regards to locations significant to Vesey.

*Image from Edward Pearson’s “Designs against Charleston”*
Combining both the primary and secondary sources that represent Charleston in the first half of the nineteenth century, a clear picture begins to emerge as to what an accurate layout would look like for a digital model. To construct this map a hybrid version of these four renderings would need to be created, and to do this accurately it will need to be scaled to size. To achieve this, identifying buildings that were definitely around in 1822 Charleston and are still standing in the city today would go a long way in giving reference points to scale a created map to size.

Figure 6.13 – 1822 map of Charleston by Douglas R. Egerton
Both Egerton and Peterson saw the merit in creating visual representation of their work. Similarly to Peterson, Egerton listed the various sites relevant to Vesey’s life in Charleston
*Image from Douglas R. Egerton’s “He Shall Go Out Free”*
There are numerous ways to go about this, but one source emerges as a particularly useful tool for identifying such buildings on a city-wide scale. Jonathan H. Poston’s *Buildings of Charleston* was created for the Historic Charleston Foundation in 1997, and is one of the first modern attempts at dating and researching all the buildings within the historic peninsula.\(^{130}\) Though not entirely accurate in places due to the incredibly large scope of the research, it offers a fairly reliable date of construction and or major alteration to each building around the city, as well as a brief description of its social and architectural history. According to Poston’s entries, there are at least 378 locations he researched that were built prior to or during the year 1822.\(^{131}\) Extracting this information to compile a list of properties and their locations to include on this map to help anchor it would be a worthwhile endeavor if this model is eventually completed. However, in light of the narrower scope of this thesis and the two sites it is creating, using a handful of landmarks to help scale the map to size and increase its accuracy is sufficient. The list below includes ten buildings that were both conclusively built prior to 1822, and closely resemble what they would have looked like at that time. The fact that these buildings have been restored to look as they would have during this period or simply continue to do so by chance is useful to note as they would be a good starting point for any modeler who picks up this model in the future to build and insert into the model first.

\(^{130}\) Poston, *The Buildings of Charleston.*  
\(^{131}\) Poston, *The Buildings of Charleston.*
List of Sites Built Prior to 1822 Still Standing in 2018

1. St Michael’s Episcopal Church – 80 Meeting Street – Built 1752-1761
2. Old Exchange Building – 122 East Bay Street – Built 1767-1771
3. South Carolina Society Hall – 72 Meeting Street – Built 1803-1804
4. Charleston City Hall – 80 Broad Street – Built 1800-1804
5. Charleston County Courthouse – 84 Broad Street – Built 1753
6. Joseph Manigault House – 350 Meeting Street – Built 1803
7. Heyward Washington House – 87 Church Street – Built 1771
8. Miles Brewton House – 27 King Street – Built 1769
9. Matthewes-Legare House - 76 Bull Street – Built 1813
10. Aiken-Rhett House – 48 Elizabeth Street – Built 1820

With our map researched and locations identified that can be included to help ground and scale it as an underlay, a few more steps can be taken before the model construction process begins. Having a clear understanding of prevalent architectural styles of the period is key within heritage models of this scale to prevent the occurrence of a reconstruction that looks completely out of place. As it happens, 1822 was a transitional period of architectural history in America. The years around 1820 mark the general end of the federal period, and the beginning of classical revival architecture.133 This transition is in alignment with the

132 Poston, The Buildings of Charleston. 77, 109, 166, 169, 182, 184, 228, 501, 605, 611.
sociopolitical climate of the time, as it marks the beginning of America searching for architectural styles that best represented the country and its ideals, rather than following European (particularly British) trends such as Georgian and Federal/Regency.\textsuperscript{134} The fact that 1822 falls into this transitional period is further proven by the uncertainty and confusion over the date of construction of the Denmark Vesey House when it was designated on the national register. The columns on the porch and certain other stylistic features in the house were more in keeping with Greek Revival architecture which proved to be a significant clue to the houses more likely construction date of the early 1830’s.\textsuperscript{135}

Up until and during 1822, architectural history suggests that the predominant styles would have been Georgian and Federal, with the appearance of Classical Revival elements.\textsuperscript{136} This means that the majority of buildings would have been symmetrical, had sash windows, and had hipped and gabled roofs. Mixed used properties were common, with many properties on King and Broad Street having store fronts on the first level with residential space above.\textsuperscript{137} There was also an abundance of wood during this period of time, and most of the properties would have been clad in weatherboard with timber frame structures beneath. A number of the civic and public buildings, as well as a great number of private residences from this period did however use brick as their primary material. Stucco and paint

\textsuperscript{135} Felzer, The Charleston Freedman’s Cottage: An Architectural Tradition. 29.
\textsuperscript{136} Roth, American Architecture, 107-130.
\textsuperscript{137} This trend becomes very clear across many of Jonathan Poston’s building histories included in Buildings of Charleston.
was common throughout much of Charleston, though research should be done to determine if a building had stucco on during the period of interest for this particular model. For instance, City Hall had exposed brick in the early nineteenth century compared to its stucco’d appearance that can be seen today.¹³⁸

Keeping these architectural styles in mind during the construction phase will be incredibly useful when faced with missing information or a miss-match of purported facts. Being aware of the main modes of transport (horse and carriage) and the consequent make-up of the roads which they would have travelled upon will also be important information to gather.

As previously mentioned, research for heritage models is a fluid process and one that really never ends. The information gathered prior to model construction lays a solid foundation to begin modeling accurately, but it must be accompanied by ongoing research to create an accurate and useful end product.

¹³⁸ Poston, The Buildings of Charleston. 166
Phase 4 – Underlay/ Map Creation

Overview

Regardless as to the scope of the intended model, having an accurate footprint to build upon is highly advisable. This might sound unattainable when attempting a reconstruction, as naturally if it is a reconstruction it no longer exists so how would one go about establishing an accurate footprint for it? Using modern geographical resources such as GIS and Google Maps, the area where the digital reconstruction is based upon can be translated into an underlay for a model. This at least guarantees spatially that the model has a degree of accuracy, and combining this with archival and online research should paint a fairly clear picture as to the boundaries and more specific locations in question.

When dealing with city-wide reconstructions, even establishing the basic street layout is no small task. Much time, effort, and research should be dedicated to building as accurate of a map as possible prior to model construction. Ultimately, the level of accuracy will depend much on the available resource from and around the time period in question, but there is certainly a baseline of accuracy that can be achieved in all models by using modern resources to at least delineate the area of focus.

Implementation

Leaning on the map research already conducted, creating a usable digital map of Charleston was the first objective of the construction phase. To achieve this, a
modern digital map of Charleston was located and converted to a DWG file that would be compatible with Autodesk’s AutoCAD. As highlighted in the software chapter of this thesis, SketchUp is compatible with DWG file’s and the map would be transferable to serve as a blueprint for the city-wide model. The modern digital map of Charleston was obtained through the GIS data sheet that is freely available through the City of Charleston’s GIS portal online. The GIS data is useful but by no means perfect, as it is often the case that all surrounding dependencies are included in the outlined footprint of the designated building. It does however still provide an incredibly useful starting point, primarily because it is available in a format necessary for three-dimensional modeling. Due to a version already being converted into a DWG file and in the possession of associate professor to the program Amalia Leifeste, this step was quickly completed.

Figure 6.14 – GIS map of modern day Charleston
The GIS map of the modern day Charleston peninsular.
DWG file courtesy of Amalia Leifeste, screen-capture by author
Having opened the DWG file in AutoCAD, the first order of business was to scale the map to be 1:1 scale, as sometimes during file conversions scale can be misread or misrepresented. Having scaled the map using a known distance within it, the process of creating as accurate a map as possible of 1822 Charleston was a matter of trial and error using the 1804 and 1842 maps of Charleston as primary sources. The two illustrative maps of 1822 Charleston produced by two of Vesey’s biographers from the 1990’s (Peterson and Egerton), provided a good reference point to aid in the confirmation of certain areas of uncertainty.

Having identified the street layout, the ten landmarks of Charleston identified in the research chapter as having been definitively built before 1822 were highlighted within the model. This process was followed by the removal of all other GIS building data within the map to clear it of all buildings that currently have un-researched dates of construction. It was also mentioned in the research chapter that Jonathon Poston posits in his book *Buildings of Charleston*, that there are roughly 378 buildings/locations on the Charleston peninsular that were mostly likely constructed prior to 1822. If the model is picked up and completed at a later date and these buildings are proven to have been built prior to 1822, then their GIS information can be easily inserted into the map from the original DWG file.

The four designated sites of significance in regards to Denmark Vesey’s life were then inserted into the map to provide the footprint for the model construction phase to follow. As seen below in *Figure 6.15*, this data is a particularly helpful starting
point for construction of the Second Presbyterian Church as much of the block is still in similar condition as it was in 1822.

Figure 6.15 – Wragg Square, Second Presbyterian Church, and the Joseph Manigault house
As seen from the modern GIS data of the block on Meeting Street including the Second Presbyterian Church, there is plenty of data to build a three dimensional model up from.

Screen-capture by author

Due to the scale of this specific project (only building two of the sites), this area of the map can be pulled as a DWG file and built upon rather than inserting the whole map into SketchUp. This will aid in the rate of processing within the software and in minimalizing the file size so it takes up less room to store. A completed version of the map was then illustrated to serve as an independent resource (Figure 5.17).
Figure 6.16 - To-scale map of 1822 Charleston. Charleston’s streets and alleys as they were laid out in 1822. The map is populated with sites significant to Vesey’s life as well as known landmarks still in existence today.

Created by author
Phase 5 – Model Construction

Overview

Dependent on which software has been selected for the project at hand, as well as the general scope or area of interest, this process will go very differently case to case. However, steps can be taken that apply to all types of three dimensional digital reconstructions, regardless of the software being used and scope of the model in question.

1. It should be accepted early on that digital historic reconstructions are a significant time commitment. Setting goals and deadlines during construction will greatly aid in the rate of completion. On the whole, the act of creating a high quality heritage model should be treated with the same rigor and scholastic fervor as an author would treat the process of writing a book.

2. The long term goal of creating a sustainable resource should remain firmly in the minds of the model builders throughout this process. Utilizing the latest technology, understanding how the final product will be made accessible and represented upon completion, and building with future improvements and additions in mind are all crucial factors to consider in assuring the models continued use.\textsuperscript{139}

\textsuperscript{139} Refer to keys of sustainability from earlier chapter.
3. The research already compiled for the model should continue to grow throughout model construction, as attention turns to more specific details such as landscape, architectural features, and specific building’s massing and appearance.

4. When nearing the completion of a building, it is easy to settle for a model that might not be completely accurate due to the amount of time spent on creating it and its similarity to known architectural styles. It is at this point when second opinions should be sought to confirm the selected format or advise on edits that could be made.

*Implementation*

For the construction of the Denmark Vesey model of 1822 Charleston, SketchUp Pro (2018) was selected for use. To begin, the completed two-dimensional scaled map of 1822 Charleston from phase four was imported into SketchUp Pro as a .DWG file. It is important to note that there are certain aspects of a .DWG file created on AutoCAD that are not transferable to SketchUp, such as hatching and the use of text. These features were removed from the original file before importation, and the map was cleaned up of any stray lines to make it as conducive to SketchUp’s geometric format as possible.

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140 This function is only possible on SketchUp Pro, not the free version. It is still possible to import DWG files to the free version of SketchUp, but this process can be lengthy and complicated requiring the use of plugins or conversions.
The map underlay was double checked to assure it was still to scale by measuring a known distance within it, before then adding textures to help identify certain areas of the model space. From this starting point the three-dimensional phase of modeling could begin in earnest anywhere on map. However, with a much later completion date in mind, the two previously identified sites of Denmark Vesey’s house and the Second Presbyterian Church are all that have been constructed for this thesis.

Figure 6.17 – Map underlay of 1822 Charleston in SketchUp Pro. This is the underlay for the model after being inserted into SketchUp Pro as a DWG file, then textured to define water and coastline.

Screen-capture by author
Denmark Vesey’s House

Apart from the basic understanding of a street block that emerged as the most likely location of Vesey’s 20 Bull Street home in 1822, this reconstruction began from almost a blank slate. It was decided that a method of trial and error would be undertaken to produce a building that most likely fit the type of house Vesey was living in from the information already gathered about him.

![Image: The site of Denmark Vesey’s house on the map underlay created for the model.](image_url)

Settling on a house type and using materials and a format that would be most defensible was established as the most appropriate approach when dealing with a reconstruction with such little information. Although a case could be made that the property at 20 Bull Street was a two story timber framed dwelling, a decision was
made to construct a simple single story dwelling. Primarily, this decision was reached due to known information about Vesey’s status and the type of house that would have been rented to a free person of color for a home and work space.\textsuperscript{141} The proximity to water that this section of Bull Street was on during the early nineteenth century also meant that a decision was made to build a raised foundation on brick piers. At this point, a number of dwellings were constructed in slightly differing formats to aid in the decision process for the final format of the house.

\textbf{Figure 6.19} – Early rendering of possible Denmark Vesey house on SketchUp Pro.
One of the early options for Vesey’s house was created with a porch and raised brick piers.

\textit{Model by author}

It was clear from the research that as with many of the lots around the city, Vesey’s rental house would have existed on a long and thin parcel of land. This lead

\textsuperscript{141} Interestingly enough, apart from the Powder Magazine on modern day Cumberland Street, there are no other surviving single story dwellings within the Charleston city limits. Egerton posits that Vesey rented a “modest, one floor structure” but fails to substantiate the claim with any evidence. Egerton, \textit{He Shall Go Out Free: The Lives of Denmark Vesey}, 83.
to the decision to produce a building that was side on to Bull Street with access via a porch to the front door.

It was incredibly important at this point in the process to defer to opinions of others with a similar background in architectural history, as it is easy for the modeler to get wrapped up in the idea that because lots of time and effort has gone into creating a model, it must be right. An alternative opinion can also highlight issues with massing and scaling that can often go unnoticed by the modeler.

Having consulted others with backgrounds in architectural history, a decision was made to greatly thin many of the visible wooden members of the model. The muntins were thinned to closer reflect Federal style window profiles and the columns on the porch were thinned to appropriate dimensions. During feedback, the brick piers were highlighted as being particularly high so were lowered to a more agreeable scale.

Adding “materials,” or “textures,” to the model was the final step of construction. SketchUp offers a plethora of built-in options to apply during this phase of modeling as there is, in addition access to a “3d Warehouse” which allows free access to thousands of other models and textures. In addition to the options provided by Sketchup, photographs can be used to create a material to provide a more realistic final product. For Vesey’s house, many of the proprietary materials were

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142 This informal consultation took place over the course of a morning, and included red-line drawings by three second year graduate students at the College of Charleston Clemson University joint program in Historic Preservation, as well as program director Dr. Carter Hudgins.

used as there was not a great degree of complexity required to represent the most likely materials. Wooden shingles were used for the roof material over terne metal that was often found in Antebellum Charleston, and a decision was made to use whitewashed weatherboarding for the siding. Contextual textures were then added to provide another layer of immersion for users of the model, though the accuracy of the layout and landscape around the house is highly conjectural.

*Figure 6.20 – Final draft of Denmark Vesey’s home on 20 Bull St. on SketchUp Pro.*

*Model by author*
Second Presbyterian Church

From the research about the Second Presbyterian Church on Meeting Street that had already been conducted, it was clear that little had changed to the exterior fabric of the building since 1822. Naturally this made the building of it significantly more straightforward than that of Denmark Vesey’s house which aesthetically speaking offered next to no information to draw from. This did however present a different set of issues to face in regards to best practices of documenting architectural information from an existing site in the context of a digital reconstruction. Due to the ultimate goal of recreating an entire city, establishing the best method of capturing information quickly and effectively was vital. It simply would not be feasible to laser scan or hand measure every existing building in Charleston that was built prior to 1822 and that still retains a significant degree of its original appearance. A decision was made to hand measure basic building envelope features that are accessible from the public right of way and use basic technology such as cameras or hand held laser scanners when possible.

Having already established the basic footprint of the building from the GIS map that served as the basis for the underlay of the model, the recording of the roof line and basic features of the building provided all the data necessary to begin modeling. These features were captured onsite using a tape measure and hand held laser distance measurer over the course of a site visit. Efforts were made to utilize

photogrammetry to capture measurements that were out of reach, but due to the surrounding trees, proximity of busy roads, and overall height of the building the rectified photos produced limited results.\textsuperscript{145}

Moreover, investigation onsite and discussion with the church’s pastor Cress Darwin lead to the conclusion that there were in fact originally doors on the north and south facades of the building. The architectural makeup of these two facades definitely supports this theory as the center section of both walls protrude outwards slightly, and both include cross gables with pediments and 4 columns breaking up three bays. All these elements combine to make a plausible case for doors originally being included in the center bay of each wall. Written research to support this could not be found, but a decision was made to include it in the final model with the intent of finding a method to represent this uncertainty visually post completion.

Using the GIS blueprint of the model and supporting its dimensions with the measuring tool on Google Maps, the footprint for the building was drawn and raised up to the measured roof line to create a basic massing model for the church. At this point the church was temporarily moved away from its geographical location on the map underlay to provide a clearer view during construction.

Adding the roof, tower, and portico were the next major steps in this process. Where measurements had been unattainable from the site visit, photographs were utilized to derive measurements that could be designated to that feature or area of the building. In the case of the Second Presbyterian Church, the tower and belfry were the main sources of uncertainty in regards to their scaling and mass, so a process of trial and error was used to arrive at a realistic conclusion.

Adding the windows, doors, and character-defining features such as the fanlights and column capitals were the next and most time-consuming part of construction. The number and variety of doors and windows at Second Presbyterian Church significantly added to the amount of time spent on this process.

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146 Uncertainty such as this during documentation can be used as an opportunity to represent visual uncertainty within the model itself, or alternative means of gathering the data can be explored.
As the Presbyterian Church is currently stucco’d almost entirely in white, with all available evidence suggesting this was always the case, the only areas that needed to be assigned a material were the windows, roof, and doors. The asphalt shingled roof that currently exists on the building is definitively not original. Over the course of the past two centuries the numerous natural disasters that have swept over the church has meant that the roof has been subjected to numerous repairs. These repairs are mentioned in a number of newspaper articles which hint at the previous material for the roof being a slate shingle.\textsuperscript{147} This type of roof certainly fits with the time period in question so a proprietary SketchUp slate texture was used on the roof.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig622.png}
\caption{The completed rendering of Second Presbyterian Church, prior to textures being added. Establishing the massing of a building with accurate measurements is the first step to building a digital model. \textit{Screen-capture by author}}
\end{figure}

The building was then transported to its accurate geographic location and some context was added to its surrounding landscape. At this point, the size of the model was creating SketchUp to slow down when trying to fulfill basic tasks, so the model and its context in the underlay was copied and pasted into a new SketchUp file so it could be completed faster and transferred back to the original model upon completion.

Landscape and context for the buildings certainly adds another layer of complexity to the model making process. It is unfeasible for researchers and model builders to research both building and architectural histories as well as every landscape feature that could or would have populated the surrounding area. A decision was made to include trees in a similar fashion on Wragg Square as they are seen today.

Figure 6.23 – The completed rendering of Second Presbyterian Church with contextual surroundings. The final version of the model above in context on Wragg Square.

Screen-capture by author
Methods of Representing Uncertainty Within Digital Heritage Models

Before moving on to post completion in the model creation process, the identification of appropriate methods of representing uncertainty or ambiguity within the model needed to be established. This issue is of particular importance to producing a digital resource that can be sustainable moving forwards as academic integrity is vital to a models ability to remain useful regardless of potential future technological redundancy.

It is dangerously assumed by many creators of digital heritage models that those who use and interact with the models do so accepting that what they are looking at is a reconstruction. Those without a background in history or the subject matter of that particular model, as well as younger audiences engaging with the model online, could easily take what they are looking at as exactly what that place or period in history would have looked like. Even if the user of the model knows that what they are looking at is not an exact reconstruction, ambiguity within the models is often completely non-existent visually. This severely undermines the integrity and effectiveness of such models as a historic resource. If digital heritage models are ever to be considered as useful, worth-while, and sustainable scholastic endeavors then academic transparency needs to be all encompassing.
The lack of a concerted effort in existing models to represent ambiguity visually is understandable.\textsuperscript{148} If the original purpose of a heritage model is to educate by creating an immersive and engaging environment, then interrupting the graphics would detract from this. Moreover, it could be argued that as a digital reconstruction, every part of the model should be visually altered as it can never claim to completely accurate. There is certainly logic to this line of thinking. However, it would be insulting to assume that everyone accessing a digital reconstruction had both no contextual information about what they were viewing and whole-heartedly believed that what they were looking at was one hundred percent accurate.

To mitigate the issue of detracting from the models effectiveness as an immersive and photorealistic resource by altering its visual fabric, two versions of the same model could be created. Both would be accessible to the public or desired audience, but one would represent the model as it was constructed with no visual alterations whatsoever that represent ambiguity. The other a model solely dedicated to representing areas of certainty and uncertainty within the model.

With no precedent to work from, three types of visual representation were tested to establish the best fit for the 1822 Charleston model. The three methods listed below were selected as they were all achievable on SketchUp Pro, and the simplicity of each method would also be attainable on almost every other modeling

\textsuperscript{148} In every heritage model studied for this thesis there has been no evidence of models representing varying degrees of certainty in a visual format. It should be mentioned that every model has included some degree of background information to provide context to the model, but this does not address the scenario in which a user is engaging the model having not read the accompanying text.
software available. The two sites built from the construction phase of this thesis (Denmark Vesey’s House and Second Presbyterian Church) are perfect candidates for this study as much is known about one of the locations, and very little about the other.

1. Transparency Scale: Altering the transparency of buildings or areas that were constructed with varying degrees of certainty. If a building is opaque then it was created from reliable sources, with the more transparent it appears meaning the less reliable the reconstruction.

2. Number System: Labelling the buildings within the model on a 1-5 scale of visual integrity – 5 being reliable, 1 being uncertain.

3. Multi-Model: Creating two versions of the same model. Having one unaltered version representing the model as built with no reference to visual uncertainty. Having another version completely altered to solely represent uncertainty.
**Transparency Scale**

Using this system, the immersion factor that is so important in engaging with users is minimally diminished. Textures and colors are all still visible, and it can be done on a micro and macro scale within the model. It alters the visual representation of the building or area enough so that regardless of the contextual knowledge the user knows about the model prior to using it, they would be aware that a message is being conveyed. Using transparency as the medium for this message makes a lot of visual sense, as the buildings lacking information look ghostly, even empty, whereas buildings and areas that are well supported look full and sure.

*Figure 6.24 – A view of Bull Street and the purported location of Denmark Vesey’s house.*

Bull Street visually represented within the model to highlight the fact that there is little evidence supporting this part of the landscape.

*Model by author*
When zoomed in on Denmark Vesey's house itself, the buildings overall shape and character is preserved despite the visual alteration. With the contextual buildings in the landscape around it, there is certainly some muddying of the image itself but not enough to deem the model unclear or less useful.

There are two ways to create this effect on SketchUp Pro, the first is incredibly easy but only works when the whole model within the workspace is being translated to this translucent texture. From the Styles toolbar, the X-Ray feature can be selected and this automatically causes everything within the model space to be represented translucently. However, when using this effect to visually represent a range of ambiguity it is ineffective as it cannot be narrowed down to work model to model. Alternatively, on a more micro-scale, specific areas can be highlighted and given a

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Figure 6.25 – Denmark Vesey's house represented through the use of SketchUp Pro’s X-Ray format. By making the building translucent, the shape and form of the house is still easy enough to make out, but the building is clearly delineated as being different from the rest of the greater model. Screen-capture by author
plain color texture, which is then edited in the materials toolbar to become translucent. The benefit of this system is that you can highlight specific areas, such as the North and South facing doors on the Second Presbyterian Church, and change them individually to a set level of opacity. This allows for a varying degree of opacity depending on how much evidence there is to support that certain architectural feature.

![Figure 6.26 - Second Presbyterian Church with areas of uncertainty highlighted by translucent textures.](attachment:second_presbyterian_church.png)

The South facing door that was included from unsubstantiated evidence is represented as being very translucent compared to the opaque nature of the rest of the structure.

*Screen-capture by author*

When this system is used in context with a written explanation accompanying the model, it has the potential to be very effective whilst maintaining the immersive nature of three-dimensional heritage models.
**Number System – Visual Integrity Rating**

A numbering system within the model offers an interesting alternative to completely altering the visual fabric of a model. Assigning a “Visual Integrity Rating” to each building or area around the model through the use of a 0-5 number system is both accurate and unambiguous. Whether the model was used or engaged with in its context or by itself, the numbering system would be an effective in representing uncertainty.

This system also provides the most accuracy of the three options being tested, as it prescribes a clear rating to each building or location. Unless accompanied by a scale bar, the other two formats of representation fail to represent ambiguity as accurately on their own. To achieve this effect on SketchUp Pro was very simple. Using the 3D Text tool from the large tool set, any phrase can be inserted and adjusted as if it were any other component of the model.

However, the use of the numbering system is far less successful on a micro-scale. If a building is designated as having a 4.5 VIR rating, as designated to the Second Presbyterian Church in *Figure 6.27*, then it remains unclear where on the model that 0.5 points worth of uncertainty is from. A number of values could be used on a single building or landscape, but this definitely crosses the line of taking the model user out of the immersive experience of using a heritage model in this context.
Figure 6.27 – Second Presbyterian Church using the Number System to represent level of ambiguity.
Second Presbyterian has been designated a Visual Integrity Rating of 4.5. This is due to the fact that
the church is largely unchanged since 1822, minus some minor features.

Screen-capture by author

Figure 6.28 – Bull Street and Denmark Vesey’s house represented with the number system.
This image is a good example of how this system could not be effective at this scale. Giving every
building and feature a rating would be visually jarring, or assigning the whole landscape a rating as
picture above is an insufficient representation.

Screen-capture by author
Overall, this system causes more harm to the overall purpose of the model than it does giving it the academic integrity it aims to provide. This is primarily because inserting text into a historic landscape, however small, detracts from the experience of being immersed in it. There may be a case for using this system in concert with another, but that would ideally exist outside of the model space.

**Multi-Model**

There is definitely a case to be made for including two versions of the same model in the final representation of a digital heritage model. This would allow for one version to engaged with in any number of formats completely visually unhindered, and another to represent through any visual means available the areas of uncertainty or missing information within. This should definitely be a viable option for anyone modeling in the heritage sector. However, a significant issue arises when the model is used out of context, or by someone who is unaware or uninterested in the second version representing the areas of uncertainty. This also has a roll over impact on the models ability to remain sustainable moving forward. Two versions of the model would need to be maintained and edited simultaneously, and the threat would continue to remain that the original model could be engaged with out of context of the second model, greatly damaging its integrity as a historic resource.

To create two versions of the same model on SketchUp Pro, two. skp files were created from the same final draft of the model. One was left completely as it was completed, and the other was given a different style under the *Styles* tab of paint
toolbar. Any style could be assigned to the model as a starting point for representing ambiguity across the model, and any color or visual theme could be employed to represent various levels of certainty across the model.

![Model of 1822 Charleston focused solely on representing historic uncertainty.](image)

**Figure 6.29** – Model of 1822 Charleston focused solely on representing historic uncertainty. A visually contrasting format was selected for the version of the model dedicated to representing varying levels of uncertainty. This allows a greater juxtaposition between this version and the original unaltered version. Screen-capture by author

Ultimately, there could definitely be a place for this method of representing uncertainty within a digital heritage model. If the format that the model ultimately ends up in, whether that's a website or video, represents the two models clearly and finds a way of interlocking their use, then it could be highly successful.
Selected Format

For the model of 1822 Charleston, a combination of the VIR numbering system and the transparency scale was utilized for the final product. This combination would involve the employment of the transparency scale within the actual model space itself, and the use of the VIR numbering system in the textual description of the model online. This format also allows the model to be interacted with independently of the VIR numbering system, and still communicate to the user which areas of the model are more ambiguous than others.

Moreover, this format is arguably the most effective method in regards to the potential sustainability of the model. It is easy to implement for those who maintain and build upon the model in its current format, it is a visual cue that will not become unclear as the model grows older, and it is in line with keeping a high level of academic integrity that is vital to heritage models ability to remain useful moving forward. This format also is compatible with the various mediums of interaction utilized for the final product of the Denmark Vesey 1822 model of Charleston.
Phase 6 – Post Completion

Overview

Like the research that precedes construction, the modeling phase is an ongoing process. There comes a point, however, when the model is deemed ready to fulfill its purpose and be made available to its intended audience. All the effort required to develop the model to this point is wasted if it is not represented in an effective format via appropriate platforms.

The decisions made as to how a heritage model is shared and interacted with will be greatly impacted by the original purpose for the finished model, but a number of questions apply to all developers during this phase of construction. How will the model be made accessible to its intended audience? What formats will the model be represented in? How can the model become a sustainable digital resource moving forward?

As far as making the model available, a dedicated website or sub-site on a company or university website is in all likelihood the first order of business for any recently completed model. Via this website, the model can be accessed worldwide and can be represented in a variety of engaging formats depending on the purpose of the created model. Alternatively, a heritage model could have been created in conjunction with a museum exhibit. In this case a 3D printed version of the model could be created as part of a greater display. Representing the digital heritage model in a number of formats across a variety of mediums is the most advisable course of action. This not only significantly increases the ability the model has to reach more people through
its range of options for interaction, but gives the model more of a chance to be sustainable and remain in use for longer.

Using the latest technology and software to engage the intended audience with the model is highly advisable. In 2018, this would mean using software and a platform compatible with augmented and virtual reality as they are at the forefront of interpretation with digital resources.

Regardless of the desired medium of representation, models should be represented with a body of text dedicated to describing the process that went into constructing the model, as well as some type of works cited or bibliography. It would also be incredibly advantageous to the model if it was launched in conjunction with an event such as an anniversary or conference, or launched alongside a concerted marketing campaign through appropriate local or national media avenues.

After a certain period of public use and interaction the model should undergo a phase of re-evaluation of its ability to achieve its intended purpose. It should also be readily available to someone involved in the creation of the model who can make edits if new information or research emerges, and for basic maintenance of the model on the various platforms it is available on.

*Implementation*

Although not completely finished, construction on the model of 1822 Charleston had to cease in order to represent the entirety of the construct phase within the time-span for this thesis. Enough of the model has been created to clearly
illustrate the post-construction process required for creating a digital heritage model. Some methods of representation have been created as if the model had been completed in its entirety for academic purposes.

Two versions of the model of 1822 Charleston that could become the final product if it the model is finished.

1. The model could consist solely of three-dimensional recreations of the sites already highlighted on the model. This version is highly attainable by one or a small group over a realistic period of time. Creating just the ten sites listed in the research section as well as the Hampstead AME church site, and the Workhouse on Magazine Street would achieve the goal of creating an interactive model to represent the life of Denmark Vesey in 1822 Charleston.

2. The second option would be to three-dimensionally build the whole city of Charleston as accurately as possible as it existed in 1822. This would require a team of people over a multi-year period to realistically complete. It would however provide a more immersive and comprehensive historic resource, as well as provide the platform for the addition of other layers of history to be represented within the model.

Completing either option above would be a worthwhile endeavor. In regards to sustainability, option number two would certainly have a better chance at enduring over the coming decades as it would have a wider reach in regards to audiences it could attract. It would also become more of a living model as more layers of history
could be represented in the future. However, taking the route of option one would allow for a realistic completion schedule with the chance to develop the model into option two in the future. This would be the most advisable course to take.

Whichever method of completion is selected, aiming for release in 2022 would be an effective strategy. This would launch the model at the 200th anniversary of Denmark Vesey’s rebellion, the year that the model represents. Moreover, releasing the model through the Clemson University and College of Charleston program in Historic Preservation would give the model a solid academic reputation to draw from when first released. A partnership with professional organizations in the area such as Historic Charleston or the International Museum of African American History would also aid in the models chances of attracting attention. Working in conjunction with a museum or academic institute could also lead to an exhibit in the future with a 3D printed version of the model or a dedicated space to interact with the centerpiece to a greater exhibition.

There is a myriad of ways in which the model can be represented and engaged with both online and in person. Without question the model would need to have an online presence, whether through a website of its own or through a link from a professional or academic organization. The layout of the website will vary model to model, but for the 1822 Charleston model the rendering below depicts a possible format that would be conducive to the models goals and capabilities.
Directing the user’s attention straight to a video of the model in a fly-through style which can be produced directly from SketchUp and then edited, is an effective way of illustrating the model's contents. The video can also serve as an independent resource and ambassador for the model on other platforms such as YouTube or social media.

**Figure 6.30** – Example of what the website for the final heritage model could look like.

Creating a website for the completed model is the first and most important step in sharing heritage models with the public.

*Rendering by author*
In addition, websites can be utilized to combine text with the contents of the model to provide context and traditional historic information. This is a pretty standard format for many heritage models available online today, and is undisputedly an effective method of representing a final product.

Using the latest technology is an indispensable requirement of a modern heritage model as it increases the models chances of being engaged with as well as keeping it relevant as a technological resource for as long as possible. Although
another plugin could be employed in the future, Kubity was used as the software of choice for making the created model available for use interactively. This particular software takes SketchUp or Revit files and instantaneously creates a platform to engage with them through film, virtual reality, augmented reality, remotely via phones or tablets, and interactively walking around within them.\footnote{Kubity's various functions are listed at their website: “Kubity,” \textit{Speak 3D}, accessed January 2018. \url{https://www.kubity.com/}. Alternatively, if the constructed model is on a smaller scale, architectural software that offers more options for realism could be employed such as Lumion. “Beautiful Renders Within Reach,” \textit{Lumion}, accessed March 2018. \url{https://lumion.com/}} A free version is available but limits users to creating one model via their software, but the full version is a relatively affordable $199 a year. The final product could be transferred to Kubity to be interacted with as a whole model, which if the entire city has been created would be an incredibly immersive and effective educational experience. Equally, the model could be broken up per location significant to Vesey's life, such as Second Presbyterian Church or his home that have already been created, and interacted with through the variety of mediums Kubity offers on a smaller scale.
Providing a ‘free to download’ app to support the software on mobile phone and tablets opens up a new realm of possibilities to the potential capabilities of heritage models. The model of 1822 Charleston has been linked geographically with Charleston so the longitude and latitude of Vesey’s reconstructed house on Bull Street and Second Presbyterian Church on Meeting Street are accurate to real life.\footnote{This is a feature available to sketchup as almost a hangover from the programs ownership by google. A google map underlay can be inserted in a satellite or clear map format through the geolocation option under the file tab, before then being edited and scaled within model space.} This means that using Kubity’s augmented reality feature, one could visit the modern day sites of the models and project the recreation on the space around them. This added dimension of engagement with model users is groundbreaking. It means that the model is effective in engaging and educating the public on Denmark Vesey and
Charleston as a city in 1822 on an unprecedented amount of levels. To interact with the augmented, virtual, and mobile features of Kubity from the desktop version, a barcode accessed within the model can be scanned and that feature activated. This also means the model or even just the barcode related to the model can be shared via social media, email, or any other online format for people to access it.

Looking further ahead, it would be highly recommended that the final product get 3D printed as both another form of interaction and for sustainability purposes. In an ideal world, the model would be finished and adopted by a university or educational organization that could use a continuous flow of students to continue to develop and build the model. This process would also allow for the students to learn
how to model in heritage and create sustainable, useful, digital resources that could serve a real purpose in the academic community.
Model Construction Review

Whether the model of Denmark Vesey’s 1822 Charleston gets completed by the desired date of 2022 or it never leaves the pages of this thesis, its construction was a success for a number of reasons. The process described successfully used the keys to modeling sustainably within heritage deciphered from a study of past and existing heritage models. It also used the evaluation of available heritage modeling software to create a model that would have the potential to remain relevant and useful for decades to come. The phases described can be referred to by heritage professionals regardless of their background or understanding of technology to create sustainable models of their own.

Furthermore, the model successfully identified three methods of representing uncertainty within a model through the use of visual cues, an area that up until this point has been missing from academic conversation surrounding heritage models.

The main goal for the development of this model was to represent how to construct a sustainable heritage model, in the hopes that others may draw from the process to aid in the longevity of such resources. The table below illustrates how the model fared when juxtaposed with the established keys to modeling sustainable established through the study of existing heritage models.
<table>
<thead>
<tr>
<th>Sustainability Key</th>
<th>Does the Denmark Vesey model of 1822 Charleston meet the requirements?</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Quality Research and Scholarship</td>
<td>Yes</td>
<td>A significant amount of research went into all aspects of the model's area of focus. This is represented in phases 2 through 5.</td>
</tr>
<tr>
<td>High Availability/Access</td>
<td>Pending</td>
<td>The model is constructed with the goal of being shared freely on multiple platforms and via multiple formats. This is discussed in phase 6.</td>
</tr>
<tr>
<td>Latest Available Technology Used</td>
<td>Yes</td>
<td>The model undisputedly represents the use of the latest available technology within the field of digital heritage reconstruction.</td>
</tr>
<tr>
<td>Multi-Purpose</td>
<td>Pending</td>
<td>The model serves its primary purpose of representing Denmark Vesey’s life in Charleston. It also would serve a purpose to those interested in architectural history, Charleston history, and in the future could visual represent other historical events.</td>
</tr>
<tr>
<td>Built to Adapt and Change</td>
<td>Yes</td>
<td>Among other things discussed in phases 1 through 6, the model was built on the most user-friendly software program available to heritage professionals. This makes it as easy as possible for others in the field to add and develop it in the future.</td>
</tr>
</tbody>
</table>

*Table 6.0 – The table above compares the newly created model with the previously identified five keys to creating a sustainable model. Comparing the model to the same rubric that was used to judge existing models, it is evident that the Denmark Vesey model of 1822 Charleston meets or is prepared to meet the criteria successfully.*
The model clearly achieved its purpose of representing the five keys during and following the construction process. In the two instances where “pending” has been used to described the ability of the model to meet the keys requirements, it is fair to surmise that these keys would be met upon completion of the finished model. The construction phase successfully represents an effort to meet those requirements post-completion of the whole model.

Each phase took varying lengths of time to complete. The figures below serve as a useful reference for anyone interested in gaging the time required to construct heritage models on this scale. It is important to keep in mind when referencing this data that they represent the time it took to run through a construction phase that only included two buildings of significance. On a city-wide scale these results can be multiplied accordingly to gage a rough estimate of the required time. It is also significant to note that this set of data is representative of someone who has a master’s degree level understanding of historic preservation, which includes a working knowledge of a number of software programs such as AutoCAD. This meant that some phases such as the map underlay construction which took place predominantly on AutoCAD is represented at a faster rate than it would be for someone new to this software.
**Phase 1 – Topic Selection**

This may seem like a phase that could potentially be over with in less than an hour, but even when an idea or plan for a heritage model is established, it still required fine tuning and ironing out prior to moving on.

**Phase 2 – Software Selection**

Roughly two and a half hours was spent selecting the appropriate software for this project. This process could be undertaken at varying speeds depending on prior knowledge of heritage software and their various capabilities.
**Phase 3 – Research**

Although difficult to put a number of the exact amount of time spent researching for the Denmark Vesey model of 1822 Charleston, it is safe to say it was significantly over fifteen hours. It was generally speaking closer to being between thirty and fifty, but it is a process that is never truly over. The great thing about a digital model is that it can always be added to and improved upon with future research, or when new information emerges. This is arguably the most important phase of construction for digital heritage models, as research needs to be of similar high standards to that of any work of academia. This is vital in allowing heritage models to become sustainable, reliable historic resources as we move into an ever growing technological age.

*Figure 6.36 – Visual representation of the amount of time spent on phase three of model construction. Research for heritage models on city-wide scales is a fluid process. Research for any heritage model should be extensive and exceed at least fifteen hours as represented above. Created by author*
Phase 4 – Map Underlay Construction

This phase of construction is designated generously as ten hours. The process of creating an accurate underlay for a digital model is although not necessary for smaller scale models, incredibly important for providing accuracy for city or townwide historic landscapes. Depending on the time period in question and how much information is available on that area this time allotment could fluctuate greatly. Using multiple maps from around the first half of the 19th century allowed for a process of trial and error to take place to establish the most accurate city layout. Most time was spent over this period on AutoCAD using a preowned copy of the .dwg file of the city GIS layout and moulding it to fit that of 1822 Charleston. The quality of research will influence the time required exponentially during this process.

Figure 6.37 – Visual representation of the amount of time spent on phase four of model construction.
A significant amount of time was spent translating research into a usable, accurate map underlay. This process would be prolonged for an individual who isn’t familiar with programs such as AutoCAD or technology as a whole.

Created by author
Phase 5 – Model Construction

Denmark Vesey’s House

Around thirteen hours was spent solely in terms of modeling Denmark Vesey’s house and populating the area around it with texture and context. This process was exaggerated as due to the non-existant nature of information about the house itself, a period of trial and error was required to establish something that could be accurate.

Second Presbyterian Church

Second Presbyterian took ten hours of modeling to arrive at an accurate and acceptable final product. This period of time is a good marker for how long it would take to be a standard historic building with good photographic evidence to work from.
Overall

It took around thirty hours to model the two sites selected for this thesis. It should be noted that the processing time for individual buildings would most likely decline as the user gets more accustomed to the software they are using.

Phase 6 – Post Construction

For as long as it took to construct the model, it took equally as long to process it and format it to be ready for public consumption. Roughly fifteen hours was spent editing the model to be suitable to the desired formats of augmented and virtual reality, and a significant period of time was spent creating scenes within SketchUp that could be transferred to create a video.
Overall, roughly one hundred to one hundred and fifty hours was spent creating the model. That would suggest that to create the model including all fourteen sites designated on the maps underlay to represent the life of Denmark Vesey an extra estimated two hundred hours would need to be spent modeling and researching. It is difficult to put an exact number on this estimate, but using the groundwork laid by this thesis this time could be spent solely on modeling, greatly reducing the time of the overall project. Moreover, these figures are representative of one persons effort to complete this model. From all the examples of existing heritage models studied for this thesis, every single one of them was created by a team or collective group of modelers. If a class of students or small group of heritage professionals were to tackle the remaining buildings for this project, it could be completed in a highly achievable amount of time.

SketchUp Pro as a software program for developing heritage models surpassed all expectation for its capabilities and user friendliness. It took up to three hours of modeling to understand the basic user-interface, and as more time is committed to the software, its expansive range of features begin to emerge. Its current capabilities are highly conducive to modern technologies and software is being developed around SketchUp that are constantly increasing its range of potential functions. It certainly has limitations in places, particularly in regards to materials and textures. They can often seem cartoonish or unrealistic if applied loosely, but

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151 See the discussion on Kubity and Lumion. Pages 148-150.
utilizing the option to use photographs as materials themselves is effective at diminishing this issue. Despite minor issues such as this, SketchUp is a triumph. On top of all of its successes as a program, the fact that it is available to anyone around the world for free is an unparalleled quality. This thesis proves that it can be employed to create both a sustainable and efficacious digital heritage model.
CHAPTER SEVEN

CONCLUSION

Analysis of five city-wide digital heritage models created in the past twenty years identified five guiding principles to model sustainably:

1. Model must be created from high quality research and scholarship to create a resource with high academic integrity.

2. Model should be available to as wide an audience as possible through multiple platforms of access to prevent any obstacles to current and future use.

3. The most current technology must be utilized during the construction of the model to insure it remains technologically relevant as long as possible.

4. The model should be multi-functional, preferably representing multiple layers of information, to insure that the model appeals to a broad range of users.

5. The model should be created to adapt and change in the future as new technology, information, or platforms of interaction arise in the future.

Despite their rather obvious nature, establishing these keys off the back of an academic study gives them authority to inform future model construction to be as prepared to tackle the threat of technological obsolescence. Following these keys during construction of a heritage model offers the best possible chance of fulfilling its intended purpose. Employing such a long term approach to a models potential
longevity also aids in the justification of the countless hours required to construct an accurate and useful heritage model.

The five established keys to sustainable construction of digital heritage models are also consistent with the standards established by the London Charter.\textsuperscript{152} The notion of high quality academic research that is transparently communicated with the users of heritage models is highlighted throughout the charter, and sustainability as a topic is central to its philosophy. The charter also addresses important issues outside of the construction of these digital resources such as the need for their storage in archives.\textsuperscript{153} It was significant for this thesis to align with the standards set by the London Charter as although it is not formally recognized internationally, universal adherence to set criteria for the computer based visualization of cultural heritage is a vital step in the development of the field.

A significant conclusion that emerged from the research of existing heritage models is that of the link between institutions and a models ability to be sustainable. Without a firm commitment from the responsible institution towards the maintenance of the model following completion, the potential lifespan is juristically reduced. This current lack of institutional commitment suggests that the majority of digital heritage models are being built with intentional obsolescence encoded into them, which poses the larger question of what period of time defines a model as being

sustainable? Do current institutions characterize a model as a success if it is used for a year after launch? The longevity of these digital heritage models is currently a secondary concern to the majority of institutions.

There needs to be a shift in the mentality of the creators of these resources towards a commitment to maintain them as they age to ensure they retain their intended purposes over time. Educational institutes, specifically universities, are well equipped to do this. Not only are there a continuous influx of students who can learn the intricacies of digital heritage modeling while adding to or maintaining a model, but there is also consistent technological and financial support for the hardware and software required.

The efforts of this thesis to understand the role of current available software towards the sustainability of digital heritage models is also vital to the current conversation surrounding the field. A basic reference point for heritage professionals who wish to engage in three dimensional reconstructions is non-existent. Through researching four of the most prominent software platforms that are available to heritage professionals, a reference table was created to provide this service. The information within was represented in a format conducive to the modern day historian, preservationist, or archaeologist, regardless of their technological backgrounds.

The extensive documentation process that accompanied the case study for this thesis also serves as a guide detailing the methodology behind the completion of a digital heritage model. The six phases to model construction represented in Figure 7.1
can be followed regardless of the software program selected for a project, and is supported by the implementation of each phase over the course of the case study. Despite the inevitable advances in technology that lie ahead, the basic principles of each phase from topic selection through to post-construction will remain pertinent.

Figure 7.1 – Flow chart illustrating the basic progression of heritage model construction. Created by author
This thesis also laid the foundation for a wider project to digitally represent Denmark Vesey on a scale suitable for public interaction. As discussed in phase six of model construction, there are two particular ways to achieve this goal. The most prudent course of action would be to limit the scope of model construction to the fourteen sites identified within this thesis.\textsuperscript{154} This would make the amount of time required to complete the model an achievable amount, particularly if multiple people are committed to its construction.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure7.2.png}
\caption{Sites that could be constructed to form the digital representation of Denmark Vesey in 1822, Charleston. Constructing the remaining twelve sites represented in the base layer of the model would suffice to serve as an engaging digital heritage model. Alternatively, the construction of the buildings listed above could serve as the first phase of a greater project to ultimately digitally recreate the entire city.\
\textit{Created by author}}
\end{figure}

\textsuperscript{154} Ten of these sites were identified in phase 3a of this thesis and are not necessarily related to Vesey as an individual, but were definitively built prior to 1822. This would visual tie the created model of the historic landscape with modern day Charleston. The two other sites central to telling Vesey’s story and which would require the most amount of attention are the AME Church in Hampstead and the Workhouse where the trials took place.
With the challenging educational, financial, and time requirements associated with constructing these types of digital resources, why should heritage professionals bother? The answer to this question is represented throughout the numerous existing heritage models and the respective impacts they have had on cultural heritage, as well as throughout the contents of this thesis.

Written scholarship remains the central platform for research and discussion in the greater academic community, but at times visual manifestations of history and culture can reinvigorate topics with new life and meaning. For instance, the architecture department at Darmstadt Technical University began a project in the late 1990s to virtually reconstruct fifteen synagogues lost during Nazi era Germany.\(^{155}\) This project culminated in an exhibit that toured the world, successfully portraying both the devastating cultural and architectural loss of these buildings, while also bringing them back to life to engage a whole new generation.

Moreover, for the individuals or professional organizations that construct the models themselves, outside of the obvious benefits of educating and engaging others with a particular topic there are many potential positive repercussions that can occur. North Carolina State University sponsored the *Virtual St. Paul’s Cathedral Project* in 2014 which explored combining a digital reconstruction of St Paul’s in 1624 with an audio experience.\(^{156}\) Not only did the model offer the opportunity for the university’s

faculty and students to internationally engage with likeminded industry professionals, but it also led to the installation of an exhibit of the model on campus. Further still, the model brought acclaim and attention to the university when it was awarded the Digital Humanities Award for best data visualization in 2014.\textsuperscript{157} The attention from the award and installation of the exhibit could also have secondary repercussions such as the attraction of potential students or the hosting of academic conventions.

Regardless of the potential benefits of digital heritage modeling, the motivation to produce these resources should stem from a more fundamental place. As heritage professionals, we have an obligation to be the translators between the past and the present; to make the past less of a distant “foreign country,” and more of a neighboring reality. Digital platforms such as immersive interactive models that support virtual and augmented reality are the new languages through which to translate the past to the next generation. Excuses of price, accessibility, and computer competence no longer suffice for those heritage professionals unwilling to embrace this new medium of engagement. The issue of the sustainability of these models against the uncertain technological climate of the twenty-first century is although concerning, not insurmountable when provisions are made to prepare for it.

Components for Future Research

The topic of three-dimensional reconstructions of historic artifacts, buildings, and cityscapes warrants more attention from the overall preservation community. The unrelenting rate of technological advancement is although troublesome to research efforts, a great opportunity to discover new uses for technology that could be beneficial to all facets of preservation.

A specific question that emerged from this thesis during the study into methods of visually representing uncertainty within digital heritage models was to do with accuracy. There is significant room for the continuum of research surrounding the level of detail included within a digital reconstruction of a building or cityscape. At one end of the spectrum of detail is the level required by architectural historians to physically reconstruct a building from a digital model. On the opposite side of the spectrum is a model with a level of detail that is clear enough to convey a building effectively, but less accurate and refined. The point where believability meets functionality is one that may vary model to model or builder to builder. Further study into what constitutes accuracy and success in this regard would contribute greatly to the overall discussion surrounding the digital representation of heritage, and identifying a threshold between the required level of accuracy for a specific purpose would be priceless information to heritage professionals.
Appendix A:

Figures Useful for the Crafting of Sustainable Digital Heritage Models

The following figures have been grouped together to form an easy to access cohort of resources that are solely relevant to the formation of digital heritage models. They are all original resources to this thesis.
Figure A.1 – Flow chart illustrating the basic progression of heritage model construction.

Created by author
<table>
<thead>
<tr>
<th></th>
<th>SketchUp</th>
<th>Revit</th>
<th>Rhino</th>
<th>3ds Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years since inception</td>
<td>18+</td>
<td>18+</td>
<td>24+</td>
<td>25+</td>
</tr>
<tr>
<td>Cost to use - 2018*</td>
<td>Free* (Pro version available for $695 a year)</td>
<td>$2,200 a year</td>
<td>$995 for permanent use, $495 to upgrade old version* (prices for windows)</td>
<td>$1,470 a year</td>
</tr>
<tr>
<td>General features/</td>
<td>Documentation rendering, reconstruction, simulation</td>
<td>Documentation rendering, reconstruction, simulation, bi-directional, programmed to represent building systems information</td>
<td>Documentation rendering, reconstruction, simulation, large or small creations, accurate, BIM compatible</td>
<td>Documentation rendering, reconstruction, simulation, animation, easily integrated with other Autodesk platforms</td>
</tr>
<tr>
<td>capabilities*</td>
<td>(All can model in 3D)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User-friendliness*</td>
<td>High</td>
<td>Moderate - High</td>
<td>Low - High Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>(For beginners)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual quality</td>
<td>Moderate</td>
<td>Good</td>
<td>Good</td>
<td>High</td>
</tr>
<tr>
<td>Platforms</td>
<td>Windows &amp; Mac</td>
<td>Windows* (Can run on OS with assistance of other programs)</td>
<td>Windows &amp; Mac</td>
<td>Windows* (Can run on OS with assistance of other programs)</td>
</tr>
<tr>
<td>Compatible with .dwg file (AutoCad)</td>
<td>No* (SketchUp Pro is)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3d printing compatible</td>
<td>Yes* (Plug in required)</td>
<td>Yes* (Plug in required)</td>
<td>Yes</td>
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</tr>
</tbody>
</table>

*Table A.1 – Comparative table juxtaposing the capabilities of SketchUp, Revit, Rhino, and 3DS Max
This table serves as a reference point for anyone interested in the capabilities of software in regards to building a 3D heritage model. All information represented is accurate as of February 2018.
Appendix B:

Resources Created to Contribute to Scholarship about Denmark Vesey

The collection of resources below were created in concert with the efforts of this thesis to digitally reconstruct Denmark Vesey’s 1822 Charleston. They are represented as an individual collection in the hopes that regardless as to the future of the digital model constructed for this thesis, they can contribute to future scholarship on Denmark Vesey in their own right.
Figure B.1 - To-scale map of 1822 Charleston. Charleston's streets and alleys as they were laid out in 1822. The map is populated with sites significant to Vesey's life as well as known landmarks still in existence today. Created by author.
Figure B.2 – Timeline of Denmark Vesey’s life.
This timeline was based on two Vesey biographies — *He Shall Go Out Free* by Douglas R. Egerton, and *The Slave Plot that Lit a Fuse to Fort Sumter* by John Lofton.

*Timeline created by Matt Amis*
REFERENCES


1822 Charleston City Directory. Accessed at South Carolina Room, Charleston County Public Library.


   https://www.autodesk.com/products/3ds-max/features

   https://3dwarehouse.sketchup.com/?hl=en


   https://www.autodesk.com/campaigns/autodesk-for-games


   https://lumion.com/


“Denmark Vesey House, Charleston County (56 Bull St., Charleston)” *South Carolina Department of Archives and History*, accessed February 2018. http://www.nationalregister.sc.gov/charleston/S10817710094/index.htm


Fletcher, Roland, Ian Johnson, Eleanor Bruce, and Khuon Khun-Neay. “Living with Heritage: Site Monitoring and Heritage Values in Greater Angkor and the


Russel, Robert. “‘An Ornament to Our City’: The Creation and Recreation of the
College of Charleston Campus, 1785-1861.” *The South Carolina Historical

Samarajiva, Prasad, Chandima Ambanwala, and Anuradha Piyadasa. “Visualisation
of Ancient Anuradhapura: A Demonstration of Digital Possibilities.” *Journal of

Study.” *International Archives of the Photogrammetry, Remote Sensing and


Skarmeas, George C. “From HABS to BIM: Personal Experiences, Thoughts, and
2010.

https://www.sketchup.com/products/sketchup-pro/new-in-
2018?ds_rl=1257435

Smith, Trish, Khanh Vo, and Marion Werkheiser. “What’s on the Horizon: Gaming,

http://www.softwareinsider.com

Stanco, Filippo, Sebastiano Battiato, and Giovanni Gallo. *Digital Imaging for Cultural
Heritage Preservation: Analysis, Restoration, and Reconstruction of Ancient

https://wiki.mcneel.com/rhino/rhinohistory

Thomas M. Malaby, Making Virtual Worlds: Linden Lab and Second Life (Ithaca, NY:

“Trimble Acquires SketchUp from Google.” *The Denver Post*. April 26, 2012, Online
https://www.tudarmstadt.de/vorbeischauen/aktuell/nachrichten_1/synagogenexhibition.en.jsp


Vertical File, 342 Meeting Street Second Presbyterian Church, accessed at South Carolina Room, Charleston County Public Library.


https://research.reading.ac.uk/virtualrome/

https://vpcc.chass.ncsu.edu/

http://visualizingdc.org/about/project-background/


https://wiki.mcneel.com/rhino/dwgeemptyinrhino


https://sketchfab.com/?utm_campaign=nonbrand&utm_medium=cpc&utm_source=adwords&gclid=EALaIQobChMlIw6Lku8iB2QIVXbbACH299w2dEAYASAAEglJ5kPD_BWe.