Modernizing Millennia

3D Models as Ethical Progress in Museum Practice

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Master's Thesis in Archaeology
Spring 2014
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Abstract

Practical knowledge of how to use digital technologies for archaeological purposes are rapidly becoming an in-demand skill set. Why we should use these technologies, however, is a subject of somewhat less discussion. Within the past decade cultural heritage management has seen a surge in tools that promise cheaper, faster and more precise data acquisition, as well as a host of software to enable easy and integrated access to this data. With increasing user expectations, what does this mean for museums which endeavor to integrate 3D modeling into their practice? This thesis will explore the chaîne-opératoire which museums progress through to adopt 3D models into their collections. Mission statements and points of ethical museum practice will be considered for each step in the process of implementing 3D model use, such as the motivations for inception, to funding, scale of implementation, maintenance, and results in the form of community support and access. The end-product is not the only valuable part of this process, nor is it the only one that can aid museums in engaging their community. By examining the ways in which 3D modeling impacts museum ethics and practice, perhaps a more enlightened justification than the technological superiority of new digital methods can be made for embracing it.

Key words

3D modeling; museum studies; ethics; cultural heritage preservation; digital archaeology, accessibility.

Acknowledgements

It is with much guidance and support that I have been able to produce this manuscript. Foremost, my dedicated supervisor Kristina Jennbert was a consistent source of thought-provoking discussion and critique, and the content of this paper would have suffered if not for her dialectic. She is able to reduce one's fear of theoretical perspectives in a single meeting, while also conveniently wording the concepts that you had yet to be able to put into words yourself. My co-supervisor Nicolò Dell'Unto has not only been a fount of practical knowledge during the trials and tribulations with my case study, he is also responsible for enabling it in the first place, and indeed for the idea of this thesis in general. He has been the patient target of my badgering since I began at Lund, when I knew only that I wanted to do something within the realm of digital archaeology for my thesis, and not much else.

I must also extend my thanks to Björn Nilsson, Mikael Henriksson and Kerstin Cassel for a multitude of reasons. Foremost, for allowing me access to finds of such great value to them. Secondly, for bringing them to Lund from Blekinge so that acquisition could take place on campus. And last but definitely not least, for never being frustrated with the technological setbacks, even when I was. Carolina Larsson and Stefan Lindgren of the Humanistlabratoriet have been incredibly generous with their assistance in modeling as well, without which my 3D model would, in a word, be mediocre at best.

My two eternal supervisors, Robert Meagher of Hampshire College, and Valerie Tillinghast, also deserve to be acknowledged here. It is my hope that with this thesis, Valerie's decades of encouragement and spell-checking can be seen to have paid off. Bob has been a jedi-like presence during the writing of this thesis. Each correspondence could not have been timed more perfectly. While probably not his intent, he did a wonderful job of reminding me of why I study things in the way I do. To the readers, this will become clearer in the following pages. To Bob, as always, thank you.

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Chapter 1: Introduction

In this section, I will discuss the background for this thesis. This will include some of my own background and motivation for researching 3D modeling in museums, my research questions, and the research history for this subject.

1.0: Personal Motivation

There are many paths that objects can take once they have been excavated. However, according to popular science magazines this post-excavation paperwork is apparently less glamorous, and thus less newsworthy than site work. When there is such a focus on the physical excavation, it is very easy to get a short-sighted view of the archaeological process. Creating knowledge for the sake of creating knowledge is of course not something we as archaeologists believe we do, but occasionally this seems to be the only outcome.

My point of departure for this thesis ties back to my previous alma mater, Hampshire College. Even before I was admitted, their motto crept into my work. *Non Satis Scire*: to know is not enough. It is this phrase that drove me to do a thesis project in place of a thesis paper for my bachelor's degree. I felt it lived up to the promise of the school much more to put on a museum exhibit of replica items – all made by students and staff, might I add – so that anyone who desired to do so was also able learn from my studies, instead of just the two people who would have been required to read my paper.

It is not enough to know how to operate the machines that collect data, nor to use the programs which process it. Nor is it enough to know the most appropriate scenarios in which to use them. To fully appraise their value, we must not simply know how to use these new tools, but why it is appropriate for us to use them. Do they meet archaeological standards of ethical practice? Can they help us to meet our responsibilities as stewards of cultural heritage? Will our museums' mission statements be propagated, or even expanded, by them? These questions are especially relevant now, as such tools are experiencing wide integration into practice. Now is the time to develop a theoretical discourse around these technologies. I know how to use digital methods. Now I want to know why, or if, I should.

It is generally acknowledged that we will continue to develop increasingly sophisticated methods and technologies to interpret our data. This can be exemplified even in the past decade, with digital technology rapidly expanding to assist in every

corner of archaeological research. However, digital conservation often takes a back seat when so many other technologies are already integrated into common practice. Total stations and Geographic Information Systems are a routine onsite presence. Methods for scientific analysis and interpretation of materials are predictable topics at any conference. But it is my personal opinion that the penultimate goal of any modern archaeologist should be to ensure the preservation of archaeological material in as thorough a way as possible, as our actions now will impact the availability of primary materials for future generations of archaeological inquiry.

Technology has advanced in such a way that it is difficult for the individual to keep up, let alone a larger organization. Museums hold diverse responsibilities, resulting in a broad spectrum of technology being available to advance one mission statement or another. As the literal guardians of a massive collection of millions of years of the world's material culture, one shared responsibility is to ensure that "collections (both permanent and temporary) and associated information, properly recorded, are available for current use and will be passed on to future generations in as good and safe a condition as practicable (International Council of Museums, Code of Ethics item 2.18)." Virtually all museum ethics codes have a similar statute: make information available for the present, and for the future. 3D modeling technology can assist in both of these goals.

There are many benefits that a wider implementation of 3D modeling could provide archaeological study, a thorough summary of which can be easily found elsewhere. Briefly, though: where collections can be difficult to access, a 3D model can be sent in an email or an entire collection of 3D-modeled artifacts can be made for viewing online. This has an impact for both soliciting professional opinions and analysis, and for educating classrooms of prospective future archaeologists. Transportation is difficult or impossible for many delicate, monetarily valuable or exceedingly old artifacts (indeed, there is a book dedicated to the process of moving alone: see Bronken et. al. 2012). With 3D modeling technology, however, this does not mean that they cannot be displayed throughout the world. Even if an artifact is lost due to being irreversibly degraded, stolen, or misplaced, the 3D model will still be there. The slow degradation from time is an unavoidable consequence that these materials already know, and in some cases even conventional conservation can diminish the scientific value of an artifact (Viñas 2009, 56). Creating a 3D model of an artifact, an excavation layer, a building or a landscape also captures the moment in

time, creating something that will not age or degrade further. This is an invaluable aspect to the future of archaeological study.

This is not an easy thing to implement, and I will not trivialize the many difficulties that make museums hold back on implementing 3D modeling. They are much the same issues that humanities are always faced with. Finding qualified people with the necessary training, giving them the proper tools, and finding time for the creation of the 3D models are no small matters. Beyond the procedural problems lies one very large, literal obstacle: the objects. With current technologies, it would take dozens of decades to complete even just current holdings, let alone future acquisitions. Finally, at every step, money is an additional barrier. The reward, however, may prove to be worth the risk. The reward is to advance a fundamental mission statement, which ensures the accessibility of museum holdings for the foreseeable future. Additionally, the necessary investment is shrinking as 3D modeling technology becomes increasingly commonplace.

Storage in a climate-controlled environment after some attempt at preservation is simply not the best our practice has to offer anymore. Anyone that has seen the small piles of rust in boxes where metal artifacts once were can attest to the need for advancement in this area. Antiquated documentation systems and data collection methods have an adverse effect not only on academic and public inquiry, but on the state of the skeletons in our closets themselves. The product of such a long, careful process should not end in a box. It does justice to neither the past or to our work as archaeologists. By creating 3D models of artifacts, we can ensure that their voices do not disappear in the following generations of archaeological analysis.

> *Society is changing much faster than we are. We must accept the need for rapid change in museum ethos and practice, even in times of financial hardship, in order to respond to twenty-first century demands – a big challenge for a profession that is notoriously resistant to change. For the necessary change to happen, we must all be futurists now.*
> *(Black 2012, 8)*

1.1: Research Questions

This thesis aims to detail a museums' chaîne-opératoire when building a 3D model collection. Using a top-down approach, it will address the ethics of each step of the decision-making process, as well as describe some of the reasons and methods that shape it. This process will be assessed through the following questions:

(1) What are the motivations for museums to create 3D models of their collections?

There are many uses for 3D models, but which are compelling enough to museum professionals? Is this seen as something profitable? Building an academic database, good recordkeeping, increased accessibility, and many other reasons are prevalent in the academic discussion. What is it that brings 3D modeling from a theoretical discussion to a concrete project within a museum? Are motivations different depending on the size or public/private status of a museum?

(2) How do museums fund the acquisition campaigns?

Finding the capital for this process is a predictable obstacle. Are there available routes that smaller, less-funded museums can take to access this technology? Can crowdfunding help museums in this venture? And what ethical concerns are there for different methods of funding?

(3) On what scale do different museums decide to digitize their collections? If not 100%, what are the limiting factors?

What factors impact the size of the digital acquisition campaign? Is it purely funding? Or are there a variety of influences? Who has a voice in deciding what gets digitized? Does public interest make a collection or object more or less likely to be digitized? Concerning the ethics of museum display, is there a certain culture or type of artifact that has generally been the subject 3D acquisition? How does this affect the accessibility of cultural heritage for academic study?

(4) Who contributes to the acquisition process, and how?

Technologies and instruments for acquiring 3D models are as vast as the artifacts themselves. Laser scanning and image-based 3D modeling are two common methods – what are the problems, and are there ways to more fully integrate museum missions with the practicalities of 3D model creation? Do museums have people on staff to help direct and oversee the process? How big of a role do third-parties play in outsourcing? And how much can volunteers and crowdsourcing really contribute to this process?

(5) How are 3D models used and organized in the long-term?

What uses are museums left with after this process is completed? Is there an accessible route to share the 3D models with academics and the public? Is there a database that relates the 3D models with other relevant information and sources? If so, is this database shared between multiple institutions? All of these questions relate to the usability of the greater academic community, and the presentation to, and engagement of the public.

1.2: Research History

The very brief history of research into use of digital technologies is short enough, even when not limited to 3D models in particular. This section of the paper will summarize a period of only 50 years. Because many of these technologies are bolstered through the development of one another, and are often more effective when used together, it is unavoidable to briefly discuss the evolution of these technologies as a whole within the museums sector. By briefly discussing a broader topic, it allows me to introduce some problems and questions that have lingered for the past half century.

1.2.1: The Development of Digital Museum Collections

50 years is a very short time in archaeology, but a very long time in modern technology. Beginning in the early 1960s, various humanities organizations throughout the world began discussing how to manage data about their collections, and how to make that data more accessible. At this time, problems with recordkeeping within many institutions were manifold: the process of documenting collections, what was deemed necessary information, and the terminology used to describe it, were all subject to the inclination of the individual curator. Perhaps the most apt description comes from an unpublished report of Smithsonian collections, made by J. Ruffin in 1967 and quoted in Ross Parry's 2007 publication: "It would seem that x number of people, keeping records in y number of ways, for z number of years leads inevitably to x times y times z or a sort of geometric progression towards chaos" (Parry 2007, 25). It was during this decade that an increased number of inquiries for information, and probably a fair amount of frustration from the museum staff themselves, finally incited action towards machinated databases. However, during the next decade, progress towards this goal in the United States was slightly less focused as the civil rights and women's rights movements shifted curators' priorities towards acquisition (ibid. 24).

As one might expect, the expansion of collections only increased the need for intensive effort towards the organization of data. A large problem throughout the 1960s and 1970s was that, though there were systems in place, the data entry was onerous (Jones-Garmil 1997, 41). This problem was eased in the 1980s as personal computers surged into use, thus lowering cost and improving computer technologies

across the board. Other issues persisted, though, in the conception and foundation of many digitization projects. Katherine Jones-Garmil concluded in her 1995 article that "there is a need to build more of an information infrastructure in our institutions. This infrastructure must include physical resources such as hardware and software, as well as human resources. (ibid. 61)" The author describes short-sighted investment strategies which at that time prevented the creation of a thorough infrastructure for this kind of data, as well as the hiring of a full-time staff to support it (ibid. 58). This problem is recurring, and will be discussed at greater length in the analysis.

Development of the 3D technologies that meet, and indeed surpass, the goal of accessibility have been spurred on in great part by "user expectations" of integrated information systems (Leddy 2012). 3D modeling within archaeology is a very recent development, becoming common just in the past decade. The first concerted effort at implementing a large-scale 3D modeling project has come from the Smithsonian Institute in Washington, D.C. 2011 was the first year that the Smithsonian Institute had a separate category for digitization (Lipowics 2012). In November of 2013, they released the first handful of 3D models online. Since then, several more models have been released, including a model of a whale skeleton, still *in situ*.

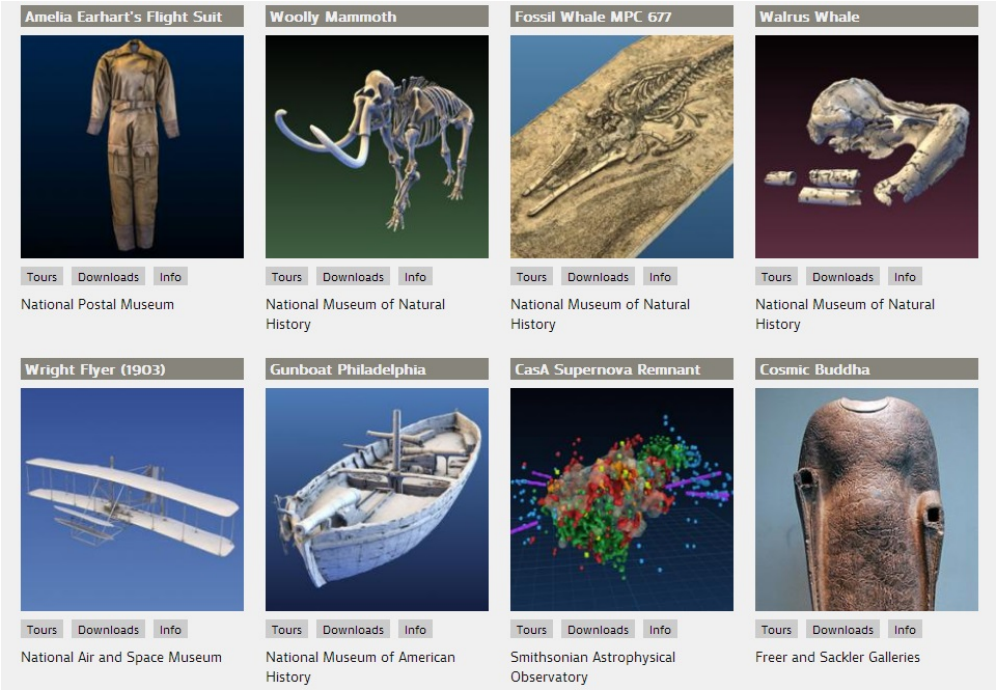


Figure 1: Screencapture of part of the 3D model offerings from the Smithsonian Institution, which can be found at: http://3d.si.edu/browser

1.2.2: Background of 3D Model Use at Archaeological Excavations

Excavation practices are developing to include 3D technology as well. Some recent excavations in Çatalhöyük, for example, have integrated a 3D workflow into their fieldwork. Tasks such as drawing excavation units have been done in a 3D-modeled excavation unit, and the larger site model includes a database of finds (Forte et. al., 2013).

This is relevant to the theme of the thesis as site practice can combine their database to both include, and be situated within 3D models. The integration of 3D artifact in the form of 3D point, within 3D site, within 3D landscape, in a program that contains a query-ready database of information about all of the above items, is approaching reality. Until then, the debate among archaeologists about how to deal with the amount of information, and how and what information will be accessible to the public, remains open.

Chapter 2: Components

This chapter concerns the elements that I will use to analyze 3D model use in museums. It will include theoretical perspectives first and foremost, followed by the more practical aspects. The method, material, and my own case study will be presented, as well as source-critical analysis.

2.0: Theoretical Perspectives

As previously mentioned, my aim is to offer a theoretical assessment of the way 3D modeling is implemented in a museum setting, and the impact that the final product has on some common missions of museums. I will use three main theoretical perspectives to accomplish this. This section begins the explanation of the elements which I use in my analysis, from ethical responsibilities to larger questions about cultural heritage.

2.1: Ethics

Museums may have technically different codes of ethics that they have set for themselves, but there are many points that have been embraced by virtually every museum. Two of these widely accepted ethical obligations are of particular relevancy to the topic of this thesis. Museums are held accountable for the care and maintenance of artifacts, and are responsible for the dissemination of information to the public.

Caring for artifacts is a basic function and ethical responsibility of museums. From international museum organizations to private museums, the survival of these non-renewable resources is a ubiquitous subject. For example, the International Council of Museums' has 8 separate points under the heading Care of Collections, beginning with:

> The museum should establish and apply policies to ensure that its collections (both permanent and temporary) and associated information, properly recorded, are available for current use and will be passed on to future generations in as good and safe a condition as practicable, having regard to current knowledge and resources. (ICOM Code of Ethics 2.18)

Conservation helps extend the shelf-life, but is imperfect. This enables a continuous reexamination through which professionals are regularly adapting their method to the

next proven best practice. Having an environment that is built around an ethical responsibility to innovate, digital technologies have a perfect proving ground already built.

The second established ethical point for this thesis is that museums are also obliged to make information from their collection available to the public. As they hold artifacts in trust for the public, the public must have access to information about the museum's holdings. Again, to quote the ICOM Code of Ethics:

> Museum collections should be documented according to accepted professional standards. Such documentation should include a full identification and description of each item, its associations, provenance, condition, treatment and present location. Such data should be kept in a secure environment and be supported by retrieval systems providing access to the information by the museum personnel and other legitimate users. (ICOM Code of Ethics 2.20)

While the way they fulfill this obligation is decided by the individual museum, the product must be comprehensive and accessible. A museum may consider their current system proficient at reaching these goals. 3D models are not positioned as well in this respect, as the organizational system of any particular museum may not be able to handle that type of information. Whether 3D models can improve upon the informative nature of a museum's database is the subject of a later chapter.

Archaeological ethics overlap these goals. "The long-term management of archaeological collections, records and reports is not just the job of a curator but a key responsibility of the field archaeologist (Sullivan 2003, 79)". The condition of each item is impacted with how carefully it is retrieved and maintained by the excavating team before being archived. Archaeologists not only find artifacts which must be kept for future study, but create them as their notes and reports. These too must be preserved and made accessible. As Brian Fagan points out in 2006, "archaeologists have a clear obligation to publish their research promptly, and in full. (Vitelli 2006, 203)" He calls attention to the fact that, though often preached, it is not always practiced.

This thesis aims to discuss whether 3D modeling technology could be another tool to assist conservators and others in the museum profession with meeting these ethical responsibilities as closely as possible. Ethical museum practice is an aspect of

each of my research questions, but has a particular presence in the first and last: the motivation, and the use of 3D models.

2.2: Cultural Heritage

Heritage is a powerful device that can serve whatever master, good or evil,
and no matter what directions museums are taking they will need
well informed and constant re-thinking and re-evaluations of their path.
Fredrik Svanberg (2010, 27)

Cultural heritage is a term that is not only used to describe a physical artifact, but also to describe the perception of an object, including its past and present use, its agency, and its recognized value to our understanding of history. In his 2010 publication, Fredrik Svanberg points out that:

> The museum is a place where collective memories are made and identities shaped. In the past and frequently in the present, this cultural production is typically characterized by an authoritative, one-way communication where the one and only truth is presented; about us, the others, the past, our country and what kind of art is good and bad. (ibid., 9)

In the same volume, Maša Avramović mentions some of the problematic uses of history, such as for political or national narratives (ibid., 125). The museum's voice in portraying narratives is not an unrecognized power. Even in recent history, we have seen authoritarian governments use cultural heritage and the institutes that curate it in order to legitimize to their agendas (ibid., 7). Cultural heritage is both preserved by the museum, and interpreted into a narrative which suits the museum's mission statements. These objects are both a responsibility and a tool.

I will use cultural heritage as a theoretical tool to help to address the issue of access covered in this thesis, particularly in the analysis of my research questions regarding scale of 3D acquisition. Differential treatment of different groups of cultural heritage (such as a Western or European bias) could have a ripple effect on academic inquiry. Having easier access to one specific cultural heritage makes publishing

information about that heritage easier. All heritage is equally important, but whether passively or purposefully, it is not always treated that way.

2.3: Chaîne-opératoire.

There is no part of the museum that is free from ethical implications

Tristram Besterman (MacDonald 2006)

I will use this theoretical concept to present the diverse set of actions needed to implement 3D modeling within a museum setting. Museums do not just display their mission statement through the product, but also through the processes they engage in. This technical act of creating 3D models has social motivations, includes interdisciplinary input, and ultimately makes a statement from the museum to its society about how the two can interact. Therefore, I believe that chaîne-opératoire will be a useful theoretical and organizational tool for this thesis in order to deconstruct and asses the implementation of 3D modeling in museums. Figure 2 shows the process that I will use, as well as some ethical and practical aspects which will be addressed.

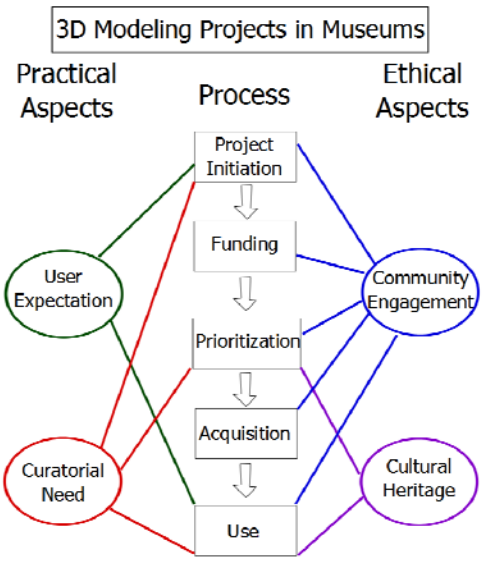


Figure 2: chaîne-opératoire for 3D model creation in museums

3.0: Material and Method

Available material about the practical aspects of artifact digitization within the humanities is plentiful, however, critical academic reflection on the use of digital technologies and theoretical perspectives are much more limited (Parry 2007, 11). By bringing in the ethical aspects of 3D modeling use, this thesis will favor the critical discourse over the technical. My information will come from the following sources.

Museum-published information will be vital to the heart of the question: why museums choose to undergo this process, and what results they expect or have received from it. The Smithsonian Institution in particular has published much information about this process on their website, and the ways they are making 3D

models of sites and artifacts accessible to the public. However, I have also found 4 other online databases which include 3D models. They will be discussed in the analysis.

Publications from a varied yet compatible section of humanities will be used to provide both theoretical and practical perspectives. The literature used in this thesis will be within the subjects of 3D modeling theory and practice, digital technologies within museums, museum practice, museum ethics, and applied ethics.

Using the materials stated above, I will utilize analytical reading to compile and compare the large amount of available material, organized by question. My methodology will combine a wide perspective from the literature with first-hand experience through a case study to address the intricacies of 3D model implementation at both a macro- and micro level.

I will create two 3D models of artifacts from Västra Vång. Being in close and sustained contact with the professionals that will be using the models will enable me to track their thoughts throughout the process, and not just once the process is over. This will also give me first-hand experience of the various difficulties that can occur, both the larger problems that have been part of academic discussion, but also the smaller, less discussed stumbling blocks as well.

3.1: A Case Study from Västra Vång, Blekinge

This section of the thesis will detail the process by which I created two 3D models of artifacts from Västra Vång. While the 3D models themselves are not a material that I cover in this thesis, the process that I used to create them was informative to the matter at hand and provides the micro-level insight to compare with the macro-level literary research. As all of my other materials are in the format of text, I thought it useful to detail the process here.

3.1.1: Pre-acquisition

I met Björn Nilsson through my supervisor, Nicolò Dell'Unto. Nilsson informed me that he had two objects in mind, both from Västra Vång. The pair was no more than 6-8 cm long in any direction, and made of bronze. Because of their modest size, we decided that one day would be sufficient for both laser scanning and photography. In

order to keep files organized, the models were named the Roman provincial model, and the local model, as we presume their origins to be. Nilsson informed me that two of his archaeologist colleagues would also be looking after our project, Kerstin Cassel whom Nilsson works with at Södertörns Högskola, and Mikael Henriksson from Blekinge Museum.

Before acquisition took place, we discussed our intentions behind making these 3D models. Nilsson anticipated using the models for 3D printing, hopefully with accurate color but of enlarged size. I asked him about his interest in future 3D modeling projects, such as building a database which included 3D models. The possibility may be in the future, Nilsson responded, but that neither the museum budget nor the excavation budget had room for such an undertaking at the moment. As I have described previously in this thesis, I was interested in the process at a macro- and micro-level. The macro-level being the chaîne-opératoire of 3D model use within a museum setting as a whole, the micro-level being creating the 3D models themselves.

3.1.2: Acquisition

The acquisition of both objects took place on February 27th of this year. In total there were 8 people, including myself, which invested time in the day's proceedings. First, of course, were Björn Nilsson, Kerstin Cassel and Mikael Henriksson, who all traveled from Blekinge to provide the models and observe the acquisition process. Both of my thesis supervisors, Kristina Jennbert and Nicolò Dell'Unto, popped in throughout the day to check up. I also had the assistance of two personnel from the Humanistlabratoriet at Lund University, Carolina Larsson and Stefan Lindgren. Not only did they provide the working space and instruments, but of course their professional opinions.

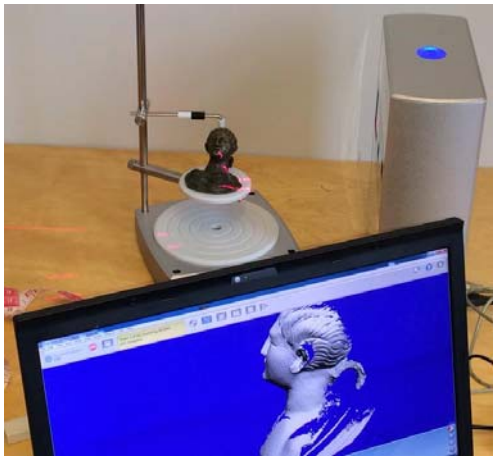


Figure 3: Set-up and first orientation of laser scanning acquisition

The scanner used was a Next Engine 3D Scanner HD. This scanner is a triangulation scanner. Triangulation scanners take a picture of the object for each

surface, and use a laser to measure the distance between a point on the object and the scanner. The Next Engine scanner in particular uses a stand that automatically turns the object once one surface has been acquired. This way, the object can remain in a single position, while still acquiring the full 360-degrees of information. Because I wanted as much data as possible, and because the time allowed, I used macro settings on both objects. This setting acquires the most dense point cloud, which results in a very accurate model, at the expense of time.

Before the acquisition took place, there were two aspects about the artifacts that needed to be considered before acquisition. First is the material: they are both made of bronze. If an object is too shiny, the light from the laser may not get an accurate distance measurement. However, these both had a nice patina on them, so this turned out to not be a problem. The biggest difficulty is that both of them are hollow. As the laser scanner can only acquire a surface that the lasers can touch, concave angles are a difficult obstacle. By placing the artifacts upright for one round of scans, and doing a second round of scans of the artifact on its side, I was able to get as much information about the bottom and inside of the artifacts as possible, with this tool. Acquiring both of the artifacts with laser scanning took just under 6 hours.

Figure 4: Second orientation

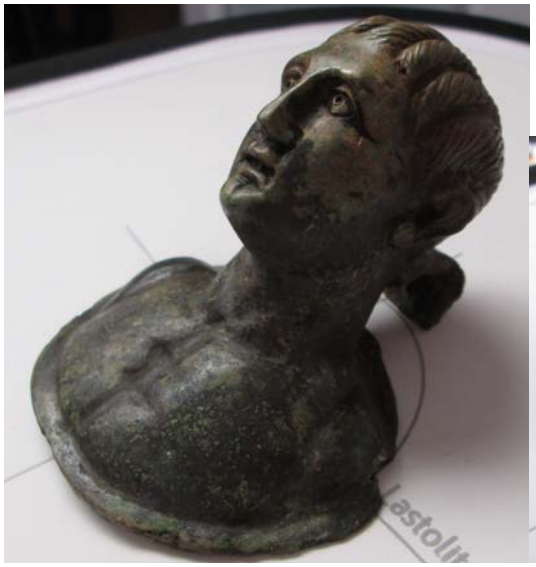
Photographic acquisition was also taken after the scanning was completed. Though laser scanners often come with photographic capabilities, they do not always provide pictures focused enough to use in image based modeling. As laser scanners do not need a high-quality photograph to work, the photographs usually only have the surface that was acquired in focus, leaving much of the rest of the object blurry. There can also be color issues – scanner photographs can have unpredictable saturation or white balance. A personal camera is a much better tool to use, whether employing a full image based modeling method, or adding texture through other means.

My own Canon PowerShot A2300 HD served the need for these small objects. I posed the artifacts in the same way as I had set them for the laser scanner, first in an upright position, then face down to the side to get the color information for the undersides. I photographed each artifact twice, to ensure a usable dataset. Each pass

was about 15 photos, including the underside. This acquisition use took about 45 minutes.

Figure 5, left: orientation for first round of photographic acquisition.

Figure 6, right: orientation for second round of photographic acquisition.



3.1.3: Processing

Using a diverse set of software, I set about turning the raw data into a 3D model. I used the software provided by Next Engine, called Next Engine Scan Studio, to do some cleaning and align the scans. After alignment, I combined the sets of scans from both orientations into full models before exporting them as .obj files for use in Meshlab. Meshlab is an open source software that allows the user to manipulate meshes in a variety of ways, from editing the geometry to applying texture. It was developed by the Visual Computing Lab of ISTI – CNR, a public organization in Italy focused on enabling research (website, CNR). It is a widely used software for the purposes of processing raw meshes into final products.

Straight away, I ran into the problem of heavy data. The laser scan resulted in about 14.7 million points per object. Processing this data was much more than my laptop with 8gb of ram could handle. Even when using Lund University's vastly superior computer labs, I still managed to run

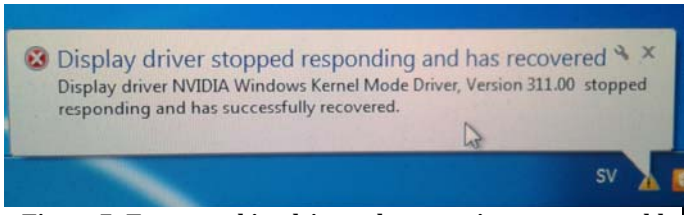


Figure 7: Even graphics drivers that were just two years old could not always support viewing of such heavy data

into problems. Because of the technical difficulties and the vast amount of options in front of me, as well as time constraints from working on the literary research for this thesis, I decided that asking for help from the professionals was the most prudent action. With the assistance of Carolina Larsson and Stefan Lindgren of the Humanistlabratoriet at Lund University, I progressed through the technical process at a rapid pace. Their computers had the power to visualize the laser scans, so with Carolina's computer we were able to make a mesh with the laser scans, import it into Meshlab, and use a command in Meshlab to make a complete single-layer mesh which would be usable by less-powerful computers. Texturing was also done in Meshlab, as the color information came out very well using the Project Active Raster to Current Mesh filter. This filter requires the model to be aligned to the same position that it is in a photograph, and the filter uses the photograph to project the same color information from the photograph on to the mesh.

The resulting models were very heavy – over 8 million polygons each. To provide flexibility with future use by the museum, I created several decimated models in Meshlab. By creating decimated models that are four million, two million and one million polygons, I hope to enable the museum to use the highest quality model possible for their future needs. The full-scale models should be proficient for future inspection, academic and public queries alike, as they have the most detailed geometry. However, all of them are equally accurate and measurable. The limiting factor for future visualization depends only on the power of the tool used to visualize the models.

3.1.4: Use of the models

The timing of this thesis worked out very well for me to see my work used immediately. Linnea Lidh, a fellow student in the master program, used the provincial model in her thesis, titled *A Roman bust from Västra Vång: a comparative study investigating the context in which the bust was created*. I am very happy to have contributed to her catalog of this type of bust.

The main goal, of course, was to create a model for Blekinge Museum. They have an exhibit running from May 31st of this year through January 2015 about artifacts from Västra Vång. The museum aimed to use tablets with the Meshlab app to enable visitors to view the artifacts fully through rotation and zoom. The anticipated

use of tablets necessitated decimating the mesh considerably, but the texture is the same across all versions of the mesh. Using the same texture keeps the visual impact of the models high no matter which version of the model is used. Unfortunately, at the time of this writing there were some technical problems with the tablets themselves that prevented this display, though the curators were optimistic for their future integration into an exhibit at the museum. I hope to keep in contact with Nilsson, Henriksson and Cassel to see where and how the models are used in the future.

Both of these uses are common justifications for creating 3D models of museum collections. Increasing access to artifacts for academic use is a great advantage of this technology, and one that I was very pleased to have enabled and seen in practice virtually instantaneously. For visitors, 3D models makes convenient the viewing of any side of an artifact without the need for physical contact or removal from a display case. This is something that both visitors and curators can appreciate. Both of these points will be discussed further on, in my analysis of questions one and five.

3.1.5: Final Remarks on the Case Study

Going through the process first-hand leaves you unable to downplay the obstacles. Not having a computer specifically for this purpose cost me a great amount of time, as did my own limited experience. When I began the process, I took photos not only to texture the models but also to attempt image based modeling. The lighting that I photographed the artifacts in was too strong, so many of the concave curves resulted in zero information, that is to say, holes in the model. My photographic acquisition was at first promising because of the consistency of color and focus, but ultimately resulted in an incomplete model with a nice texture.

One of the points that is made repeatedly in Graham Black's *Transforming Museums In The Twenty-First Century* (2012) is that museums must know "what they are for". Museums need to know what their mission is prior to undertaking new activities. As it became clearer that the laser scans were the best way to complete this project, I felt this point very strongly. I was aiming for some specific outcomes: to make a highly accurate model, as these artifacts might not get this treatment again for some time, and to have a result that is usable for visualization by the museum. These goals were best met by using the impeccably accurate laser scans, and photographs

simply for the color information. The more I kept my mission in mind, the more smoothly the project progressed.

Interpretation does not sound like it should be a concern with laser scanning. However, the acquisition and processing are highly dependent on the individual creating the model. While the laser scanning acquisition may vary slightly depending on the position that the object is acquired in, texture is a much more creative process. The photographic acquisition could have completely different results depending on who was taking the photos, the camera and settings they might use, what angles they photograph at, and the environment that they decided to do the acquisition in. This is all before the plethora of available options for using those photos to apply the color. It might seem striking to the unfamiliar museum visitor, should they witness how manual a process it can be. How to communicate this to the viewer is something that I see museums grappling with in the future.

Figure 8, left: Provincial model, front view.
Figure 9, right: Local model, front view.

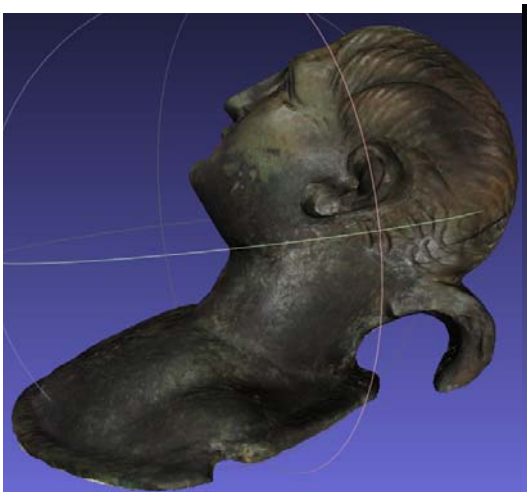



Figure 10, left: Provincial model, side view
Figure 11, right: Local model, side view

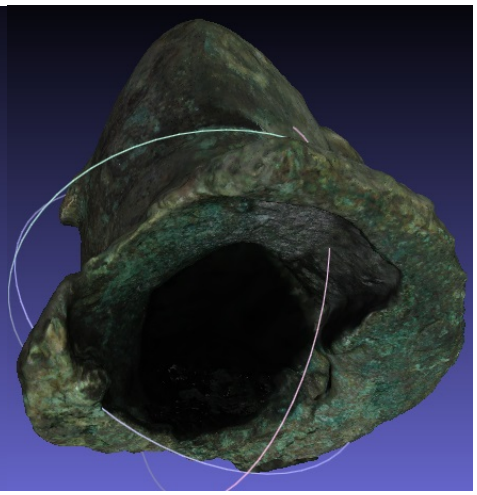



Figure 12, left: Provincial model, bottom view
Figure 13, right: Local model, bottom view.

4.0: Source, Method, and Theory Criticism

There are sources which I must be critical of in this thesis. First and foremost, myself. I have been training in digital acquisition for only a short time, so I used the methods that I was familiar with, and had convenient access to the tools for. These two methods do not necessarily reflect the most effective tools for any given acquisition a museum might want to undertake. However, though I don't have practical experience with some of the other common methodologies, I am very strong with these two in particular. Because of my training in 3D modeling specifically for the purposes of cultural heritage preservation and use, I am better suited to this type of project than an archaeologist who doesn't know the methodology, or a technician that doesn't know the material and theory.

Quantifying ethics for a diverse practice such as museums and collecting is not straight-forward. Especially as *ethics* are by definition not *law* and are thus "ostensibly self-regulating (Marstine 2011, xxiii)", there can be questions of how rigidly these codes guide behavior, both for the profession in general and institutions in specific. Additionally, Amelia Wong reminds us that "museum codes of ethics are intended to be living documents (Marstine 2013, 35)". For the sake of this thesis, I felt the best way to get the overall picture of museum ethics was to use the largest museum organization I could find, in this case, the International Council of Museums. While I also found many museum organizations with specific countries, to get the most representative perspective on current museum ethics I decided that ICOM's forum of experts from 136 countries was at least qualified to set a standard.

There is an obvious data bias in this thesis towards the United States and the rest of the Western world. My reliance on The Smithsonian Institution in particular is of course not ideal. However, there are many reasons why they have so much useful data for a study such as this. First is that they are a federal institution, which necessitates much of their reporting to be done in a publicly available fashion. They simply publish more data about their operation than many other museum institutions. Smithsonian also has a very large budget, which enables them to experiment with new ideas. Because they have such a big presence, they often get wide news coverage; something that I also took advantage of in this paper in order to have multiple perspectives on the same source, which I believe should somewhat relieve the source-critical analysis of this source in particular. As a whole I would have preferred using more equally-distributed sources, but unfortunately I was not able to find any specific cases of non-Western 3D model use. Whether due to language barriers or different reporting habits, the lack of these sources has left a large part of the world out of this thesis. I hope to rectify this through continuing my research of this methodology, and create an annotated bibliography so that future research can be more representative.

There is a Western bias present in the data, but the idea altogether is also biased towards first-world countries in general. This discussion will only benefit the less than 40% of the world population that has access to the internet. Obviously, this is not a subject I could address in such a small format as a thesis, nor is this a problem just for the humanities. However, by deeming the objects under our care as the heritage of the world, we do share common cause with educators in all subjects to try to expand accessibility to the majority of the world that at present cannot access this

knowledge by any means. Additionally, as museums in first-world countries undoubtedly hold material remains from these unconnected communities, it is particularly troubling that the communities themselves do not have access to these items. I have no suggestions for how to go about improving this situation, but as one of the primary perspectives in this thesis is cultural heritage, the more I wrote about this subject, the more that this became the elephant in the room. Computer visualization is great for expanding audiences in first-world countries. But for over 60% of the world population, this methodology does not help with accessibility. It is because of this that I personally have come to believe that conservation is the most effective justification for creating 3D models of cultural heritage, and not, in fact, accessibility.

Chapter 3: Analysis

In this section I will analyze each step in the process through a comparative analysis both of the practical point and the pertinent theoretical implications, as well as with literary research and first-hand experience through case study, where applicable. The ethics and responsibilities of museum practice will be the premier issues.

5.1: Beginning the process

There are many publications from the last two to three years which cite the need for change in museum practice (c.f Black 2012, Falk 2006, Hein 2000, Herman 1997, Svanberg 2010,). Faced with an abundance of options on how to update and keep relevant, some museums have started to choose 3D modeling as a way to engage their audiences outside of the museum's walls. What reasons are compelling enough to museum professionals to pursue the process of acquisition and implementation of this technology? How does it transition from idea to plan?

It is important to note that as technology progresses, these goals do seem to change. In the Institute for Museum and Library Services report, titled *Status of Technology and Digitization in the Nation's Museums and Libraries*, there are differences in the reported goals from 2001 to 2004:

FIGURE 34
GOALS FOR DIGITIZATION ACTIVITIES

Goal	Survey year	
	2001 (n=230)	2004 (n=382)
Preserve materials of importance or value	31.3%	48.7%
Increase access to collections/materials/files	6.1%	56.0%
Minimize damage to original materials	32.6%	33.0%
Provide access to materials via the Web	25.7%	30.6%
Increase interest in the institution	17.0%	20.7%
Save space in the institution	20.4%	4.2%
Present more of the collection than is on display at any one time	4.8%	10.5%
Save costs by eliminating duplication of materials	1.7%	2.6%
Provide access to materials for specific audiences (e.g., reserve room materials for students)	0.0%	3.4%
Encourage cooperation among institutions to increase the number and variety of materials available	26.5%	0.8%
For distance and other e-learning programs	0.0%	2.1%
Provide greater information about the institution's collections to artists, scholars, students, teachers, and the public	0.9%	18.1%
Increase access to state services	16.1%	1.0%
For our institution's internal records	0.0%	15.2%
Support educational programs	3.0%	9.7%
Other (please list)	0.0%	1.0%
Don't know/Not applicable	27.9%	11.0%

Note: Data are based on responses to survey question 31; respondents were asked to select their institution's top three goals.

Figure 14: Museum goals when undertaking digitization projects.
Source: Institute for Museum and Library Services, 2006: 37

Preserving materials of important value and minimizing damage to original materials were both two of the top three answers each year. However, a huge amount of museums realized the potential for accessibility through digitization in the three-year period between surveys. In my experience with the group from Västra Vång, they were intending to generate public interest in their unique site finds. However, I included many versions of the models so that if they have ideas in the future for how they would like to use the 3D models, they can do so easily. As we further develop technologies to further our goals, it seems that we will find other strong uses along the way that may in turn affect our use of them.

The voices of museum professionals have been very useful here, both in press interviews, personal conversations, and in published work. Much of the publicity about 3D modeling in cultural heritage projects has focused on the end product and what can be done with it. While final outcomes are certainly exciting for the development of this technology and important for museums in order to judge its effectiveness, the motivation behind implementing 3D models are also informative. When professionals who have been through the process already are provided with the opportunity to state their institute's motivations, we can understand what their museum believes their roles are in society, and how they believe this process demonstrates that role. Additionally, identifying the catalyst and tying this to mission statements may help other museums determine if this process can help them reach their similar goals.

The motivation which recurs throughout the subject of integration of digital technologies is user expectation. To quote Holly Witchey of Johns Hopkins University: "Our audiences simply expect integration (Leddy 2012)." From articles on subjects as wide-ranging as databases as a whole (See: Cameron 2007, Bertacchini 2013, Ioannides 2012, Ioannides 2010, Keene 1998, Perry 2007, Zhou 2012,) to specific digital methods (See: Ioannides 20102, Ioannides 2010, Stanco 2012, Whittaker 2009, Zhou 2012), much of the impetus comes from "users" expectations.

The goal affiliated with this motivation is also phrased in a consistent way: to turn "visitors into users" (Black 2012, 18). By taking advantage of new technologies, museums are looking to change the occasional visit, and visitor, into a continuing engagement outside the museum's walls. Access is not only about decreasing the geographic element, but also the temporal one (Falk 2006, 195). Decreasing the amount of time that a visitor must invest in order to view a collection is much-

appreciated in the 21st century. Günter Waibel of The Smithsonian Institution, for instance, notes that 3D models can be used in the classroom "as the scaffolding to tell stories or send students on a quest of discovery" [(http://3d.si.edu/about)]. This goal is consistent with virtually all codes of museum ethics, summed here in part of ICOM's fourth principle: "Museums have an important duty to develop their educational role and attract wider audiences from the community, locality, or group they serve." When those audiences are continuously adapting to new technology (Black 2012, 3), it could be in the museum's best interest to facilitate them – perhaps it could even be considered their responsibility to do so.

Waibel also provides justification from a collections point of view. On the previously cited webpage, he notes two points in particular: that this will help track degradation of artifacts, but also that this will make available the other 99% of the Smithsonian's collection that is not on display at any given time. Items that are not displayed serve limited, if any use. Museums can justify 3D modeling of these artifacts as creating ways to use their holdings more efficiently, for both public and scholarly use.

The catalysts for bringing 3D modeling into museums are multi-faceted. From the viewpoints of collections, community expectations, and community engagement, museum professionals are starting to see this technology as a tool worth investing in so they can have more interactions with users and better care for their collections; two main principles of museum ethics.

5.2: Funding the process

3D modeling is funded the same way any other museum project is. With this section, the monetary resources granted to such endeavors will create a setting within which the theory and method will act. I will present some changes in budgeting, outlook, and fundraising for digitization technologies that will help to answer the following questions. If a museum decides that the use of 3D models can be justified and is congruent with their institution's goals, how can they afford this process? Are there any different routes to funding that new digital technologies have opened? And how effective and ethical are attempts at crowdfunding cultural heritage?

Funding is always a problem within the humanities. Especially in the past decade museums have consistently witnessed budgets shrink. In a report from 2006, a report on the state of digital technology in museums for the United States found that

60% of museums reported not having enough funding for their technology needs (Institute of Museum and Library Services 2006, 14). Since then, not all museums have seen their resources restored to pre-recession levels. Even the Smithsonian Institution, for example, may just be getting their pre-sequester collections budget restored in financial year 2015, pending approval by congress (Smithsonian 2014, 10). Collections are expensive to maintain, even when not doing state-of-the-art digital acquisition. To quote Nancy Moses from her 2008 publication: "Though not alive, the stuff is voracious; unless carefully checked, it will devour the budget (2008, 1)."

One great resource to study the finances of digitization projects are the yearly publications from Primary Research Group Inc, titled International Survey of Library and Museum Digitization Projects. Their incredibly thorough surveys will provide hard data for this question, as is necessary for talking about the real financial value that is invested. They have also provided some data on the outlook that libraries and museums have about fundraising in the future that will be useful here. There are some problems with using such an inclusive survey, namely only 22.39% of their sample being museums; of the US institutions surveyed, 25.49% are museums, and only 12.5% for all other countries combined (Primary Research Group 2014, 33). However, the type of data that museums reported in the survey is 80% aggregate data, i.e., about no specific project or collection, which is the highest percentage of the four types of institutions surveyed (op. cit., 39), and is very good for this thesis. I will use their previous publication from 2008 for comparison with these points. Though different institutions may have been used for the different reports, I consider the dataset large enough to show trends. Lastly, 3D modeling is not specifically covered in either of these reports, so this source material will serve as a starting point for more specific discussion later in this section.

Beginning with the overall budget for digitization, their reports show a large difference between 2008 and 2014. Figure 15 (on the following page) shows the table from PRG's 2008 publication, Figure 16 (on the following page) shows the 2014 report. Mean, median and maximum annual budget have all increased. Mean has increased by 29%, and the maximum has increased by 56%, but the interesting data here is the median, which has gone up by a staggering 556%. Understanding these three numbers together, we can see that the lower-level funding has risen considerably over the past several years, even with all of the funding challenges that museums have faced.

Table 1.3: Mean, Median, Minimum and Maximum Annual Budget for Digitization Projects (in US$), Broken Out by Type of Library

Library Type	Mean	Median	Minimum	Maximum
College/University Library	107,813.47	13,500.00	0.00	1,000,000.00
Museum	27,278.14	3,047.00	0.00	150,000.00
Public Library	54,313.25	7.50	0.00	1,050,000.00
Special Library	227,059.40	5,000.00	0.00	1,962,791.00

Figure 15: Primary Research Group 2008, 26.

Table 5.3 What is your annual budget ($) for the digitization project or projects for which you will be giving data? Broken out by Type of Organization

Type of Organization	Mean	Median	Minimum	Maximum
College or University Library	39561.20	5000.00	0.00	276720.00
Museum	35258.33	20000.00	0.00	235200.00
Public Library	71002.00	28910.00	0.00	241920.00
Special Library	118334.33	50000.00	1000.00	500000.00

Figure 16: Primary Research Group 2014, 65.

These results are especially interesting when looking at the next set of figures. Figure 17 shows the 2008 report, and Figure 18 (on the following page) shows the 2014 report regarding the outlook for raising funds outside the museum budget for digitization. Favorable outlooks lost 2%, while unfavorable outlooks went up. This is somewhat congruous with the projections in Figures 19 and 20 from 2008 and 2014, respectfully (on the following page). These show estimations for the digitization budget for the two years following the reports. In the 2008 table, all museums estimated that the budget would remain the same or increase. In the 2014 report, however, over 6% report that it could decrease substantially and over 13% that it could decrease somewhat. Additionally, expectations that it will rise substantially are up 15% from 2008, to over 26% in the current report. Taken together, projections on both the museum digitization budget and finding funds from outside of the museum are partially pessimistic.

Table 2.23: Outlook for Raising Money for Digitization Projects from Outside Sources, Broken Out by Type of Library

Library Type	Not Favorable	Not too Bad	Pretty Good	Excellent
College/University Library	17.31%	48.08%	30.77%	3.85%
Museum	16.67%	44.44%	38.89%	0.00%
Public Library	27.27%	45.45%	18.18%	9.09%
Special Library	27.78%	27.78%	38.89%	5.56%

Figure 17: Primary Research Group 2008, 34.

Table 6.3 How would you describe the outlook for raising money for digitization projects from sources outside of the main library museum or other main institutional budget? Broken out by Type of Organization

Type of Organization	No Answer	Not favorable	Not too bad	Pretty good	Excellent
College or University Library	7.69%	30.77%	42.31%	19.23%	0.00%
Museum	0.00%	26.67%	46.67%	26.67%	0.00%
Public Library	0.00%	22.22%	33.33%	22.22%	22.22%
Special Library	5.88%	64.71%	17.65%	0.00%	11.76%

Figure 18: Primary Research Group 2014, 68.

Table 2.28: Course of Probable Spending for Digitization over the Next Two Years, Broken Out by Type of Library

Library Type	Decrease Substantially	Decrease Somewhat	Remain the Same	Increase Somewhat	Increase Substantially
College/ University Library	0.00%	5.88%	23.53%	56.86%	13.73%
Museum	0.00%	0.00%	38.89%	50.00%	11.11%
Public Library	18.18%	0.00%	27.27%	36.36%	18.18%
Special Library	0.00%	0.00%	27.78%	44.44%	27.78%

Figure 19: Primary Research Group 2008, 35

Table 7.3 Which phrase best describes the probable course over the next two years of your institutional spending for digitization? Broken out by Type of Organization

Type of Organization	No Answer	It will probably decrease substantially	It will probably decrease somewhat	It will probably remain the same	It will probably increase somewhat	It will probably increase substantially
College or University Library	7.69%	11.54%	3.85%	19.23%	53.85%	3.85%
Museum	0.00%	6.67%	13.33%	40.00%	13.33%	26.67%
Public Library	0.00%	22.22%	0.00%	22.22%	33.33%	22.22%
Special Library	0.00%	5.88%	5.88%	41.18%	29.41%	17.65%

Figure 20: Primary Research Group 2014, 72

In terms of ethical perspectives, funding is controlled not only by ethical codes, but also by law, which is fairly non-theoretical. However, looking to mission statements during this step may be a useful addition. Community engagement is something that museums strive for (Västra Vång included), and with the rapid expansion of crowdfunding, this could be a new area of interest and involvement for public audiences. In the best case scenario, it could even turn supporters into longer-term investors in the museum's future. This idea has been the focus of many smaller

reports in the past two to three years. In terms of widening audiences, crowdfunding removes the geographic restrictions usually associated with fundraising from the community (Agrawal 2011). This could help individual institutions bring in new visitors, who can be seen as new investors. Nora Caplan-Bricker asks: "why not give the taxpayers a chance to vote with their pocketbooks? (2013)" Her article points to crowd-funding successes, such as a Smithsonian Institution exhibit about yoga which ultimately raised more than its goal. Allison Peck, a representative of two galleries under the Smithsonian Institution's umbrella, stated during the announcement of the yoga exhibit that "crowd funding could be the wave of the future, […] It's been small organizations for now, but I don't see why big organizations wouldn't be able to do it (Kurtzleben 2013)." Any method that works for institutions regardless of size should theoretically be a positive development. Even the Louvre has resorted to "participatory financing (Carvajal 2012)" to fill the gaps.

Caplan-Bricker, however, also points out some cautionary tales. One example will be discussed later in this chapter, as it concerns crowdsourcing. In terms of funding, it is advantageous to the rest of museum practitioners that an institution as large and well-funded as the Smithsonian is willing to experiment, and sometimes fail, with new sources. The Hirshhorn gallery made just over 1/7th of its goal for the display of an Ai Weiwei sculpture (Caplan-Bricker 2013). Caplan-Bricker called it "a premonition of what would happen if the Smithsonian ever trusted the whims of the public, not the judgment of curators, to determine its schedule."

3D modeling is a very new technology, and professionals are looking for new ways to pay for it. Digitization at the Smithsonian Institution apparently didn't even merit becoming a line-item in the budget until fiscal year 2012 (Lipowicz 2012). Guidance on this subject is limited, and ICOM funding principles are very broad. "Income-generating activities should not compromise the standards of the institution or its public (ICOM Code of Ethics 1.10)," but otherwise, it is up to the individual museum to determine their priorities in this area.

5.3: Scale of implementation

The biggest obstacle for 3D modeling is time. Financial problems wax and wane, but time is the largest immovable force which prevents large-scale acquisition campaigns. This will be the case for many years to come. Acquiring data, processing and creating

a model, and integrating the model into a database takes hours of skilled work. To recap, my case study took about 4 hours per object for acquisition. Processing easily tripled this time, and I only had to create two models. With billions of objects in museum collections, how are they prioritized?

FIGURE 33 DIGITIZATION POLICIES							
	2001 (n=251)				2004 (n=401)		
Policy	Not checked	Policies in place	Policies in development	No policies in place or in development/ Don't know	Policies in place	Policies in development	No policies in place or in development/ Don't know
Access	12.4%	4.8%	7.6%	75.3%	23.0%	21.7%	55.3%
Best practices	16.3%	2.8%	5.6%	75.3%	8.6%	22.1%	69.4%
Conversion of digital files to next-generation formats	21.9%	0.8%	2.0%	75.3%	7.4%	17.6%	75.0%
Digital format (e.g., TIFF, GIF, PAL)	12.7%	6.4%	5.6%	75.3%	21.2%	17.9%	60.9%
Evaluation	19.1%	2.0%	3.6%	75.3%	8.4%	16.2%	75.5%
Intellectual property issues	12.7%	4.4%	7.6%	75.3%	15.7%	19.8%	64.5%
Materials to be digitized	11.6%	5.2%	8.0%	75.3%	21.3%	22.3%	56.4%
Priorities for digitization	9.6%	6.4%	8.8%	75.3%	18.8%	21.6%	59.6%
Preservation	14.3%	3.2%	7.2%	75.3%	19.8%	24.4%	55.7%
Quality control	16.7%	3.2%	4.8%	75.3%	14.8%	19.7%	65.5%
Standards	15.1%	4.4%	5.2%	75.3%	16.3%	21.0%	62.7%
Other	11.2%	13.1%	0.4%	75.3%	3.8%	2.9%	93.3%

Note: Data are based on survey question 16; respondents were asked to select all that apply.

Figure 21: Current and developing policy matters in museums
Source: Institute of Museum and Library Services, 2006: 36

Prioritization is a necessary but problematic reality. The Smithsonian Institution has stated that its plan is to acquire all of its artifacts eventually, but at the present time they have prioritized 10% of their collections. Considering the 137 million objects in their care, they have estimated that "capturing the entire collection at a rate of 1 item per minute would take over 260 years of 24/7 effort (http://3d.si.edu/about)." In their report from 2006, the Institute of Museum and Library Services found that from 2001 to 2004 there was an increase in policies in general for digitization practices, including priorities, however the majority still did not have policies for much of this process (Figure 21). What is curious, then, is how little the process of prioritization is discussed in academic theoretical perspectives.

In their 2014 report, Primary Research Group asked its respondents about how they prioritized their collections. The report is a very informative one for this question, but unfortunately, it is also one of the only resources where I could find an answer to this question. Conveniently, the data is very representative. The deterioration, material and general conditions of collections, rarity, grant funding, curatorial judgment, interest by staff, funders, volunteers and patrons, and mission statements are just part of the criteria represented in the responses (2014, 103-105).

Here again, it is important to understand the individuality of mission statements at separate institutions. One respondent stated that "We refer to the mission of the museum and decide which collections fill the most facets of the mission and have started with those (op. cit., 105)." This quote could apply to every section of this thesis. I have already discussed the importance of considering mission before action, therefore I will not spend more time here on this specific concept. It does, however, provide some context for this question.

This section has the most ethical quandaries, all of which stem from the overlapping priorities concerning collections. At its most basic, this is a conflict between the desires of patrons versus the needs of deteriorating collections. Museums have a responsibility to make collections available to the public. If a patron asks for a 3D model, one can be made and used for any patron that desires the same thing at any point in the future. However, as there is a finite amount of time that staff has to create models, does this need take precedence over delicate and deteriorating collections? This conflict brings a need for more data, and more discussion.

One of the major problems with how museums decide what gets prioritized is that it is generally underreported. Even the Smithsonian with its high visibility has simply stated that much of the decision making is left up to the individual museums which nominate objects from their collections to be digitized (Jarvis 2013). Such a short answer leaves plenty questions open. Are they given criteria? Are they asked to justify their choices? What are the factors they consider? This is a particular problem for what Swain calls "The Great Civilization Museums (2007, 35)" that represent a variety of time periods and cultures.

A quick examination of the benefits of digitization fits well here to remind us of what treatment some, but not all, artifacts are currently receiving. 3D models can be exciting for visualization to the public – the models can generate public interest in a location in space or time. For academic use it is a huge benefit to remove the burden of geographic location from the study of artifacts. Conservation of these artifacts in digital form is unmistakably meaningful for archaeological study in future generations.

Cultural heritage should all be considered equally important. This idea has been present for some decades, but has practical and theoretical difficulties in implementing a type of guideline on the subject (Omland 2006). It is a dangerous route then to attempt to justify the significance of one type of cultural heritage over

another, and yet this is essentially the task. Making these decisions, museums whether consciously or unconsciously are promoting the creation of knowledge within certain areas, and not in others. By making 3D models of selective parts of their collections, museums decide which artifacts survive through both natural disasters and natural degradation, keep their context after misplacement, loss or theft, and of course, which will be available for future academics to study and future communities to learn from.

The museum community can arrive at an ethical practice for this new methodology. However, it begins with discussion and reporting. We cannot study the implications if there is no data. The institution of the museum has immense power in the creation of knowledge as its roles of both forum and actor (Svanberg 2010), and it is the responsibility of the museum community to be constantly scrutinizing the methods by which it creates knowledge. Prioritization of 3D modeling is necessary, predictable, and conspicuously underreported.

5.4: The People and the Process of Acquisition

Finances and time are not the only limits. People are also resources that museums often do not have enough of. From a survey conducted in 2004, the Institute of Museum and Library Services reported that 65.9% of museums in the United States "do not have enough skilled staff to accomplish their technology activities (2006, 22)." Museums are not solely reliant on their staff, however. The report also has statistics for digitization done by volunteers, which 35.4% of museums in the US reported using (op. cit., 26). Contracted staffers were also used by 14.1% of museums (ibid.). Now that this data was collected almost a decade ago, where are we now? Are museum staff predominantly in control of this process, or are contractors and volunteers still relied upon?

The continued need for skilled workers is plainly apparent when considering the outlook on time spent by staff on digitization projects. Primary Research group reported both in the 2008 (Figure 22, on the following page) and 2014 (Figure 23, on the following page) that only a small amount of museums estimated that they would spend less time on digitization projects in the future, whereas 94.45% of museums in 2008 and 86.67% of museums in 2014 expect the amount of time allotted to remain the same or increase.

Table 3.13: Predicted Trend in Use of Labor on Digitization Projects, Broken Out by Type of Library

Library Type	Staff labor spent on digitization will drop significantly.	Staff labor spent on digitization will drop.	Staff labor spent on digitization will stay about the same.	Staff labor spent on digitization will increase.	Staff labor spent on digitization will increase substantially.
College/University Library	0.00%	0.00%	30.77%	55.77%	13.46%
Museum	0.00%	5.56%	16.67%	72.22%	5.56%
Public Library	18.18%	9.09%	54.55%	9.09%	9.09%
Special Library	0.00%	0.00%	33.33%	50.00%	16.67%

Figure 22: Primary Research Group 2008, 44

Table 11.3 Over the next two years do you expect that: Broken out by Type of Organization

Type of Organization	No Answer	Staff labor spent on digitization will drop significantly	Staff labor spent on digitization will drop	Staff labor spent on digitization will stay about the same	Staff labor spent on digitization will increase	Staff labor spent on digitization will increase significantly
College or University Library	3.85%	0.00%	11.54%	26.92%	46.15%	11.54%
Museum	0.00%	13.33%	0.00%	46.67%	26.67%	13.33%
Public Library	0.00%	11.11%	11.11%	33.33%	22.22%	22.22%
Special Library	0.00%	5.88%	11.76%	23.53%	41.18%	17.65%

Figure 23: Primary Research Group 2014, 87

Outsourcing to third parties is a small but consistent part of museum digitization. Only about one quarter of museums surveyed had outsourced digitization (Figure 24). It is an even smaller practice when looking at Figure 25 (on the following page), which shows that those museums only sent about 5% of their digitization work to third parties over the past three years.

Table 16.3 Has your organization outsourced digitization, in whole or in part, to a third party, another college or museum, private consultant or company? Broken out by Type of Organization

Type of Organization	No Answer	Yes	No
College or University Library	7.69%	53.85%	38.46%
Museum	0.00%	26.67%	73.33%
Public Library	0.00%	88.89%	11.11%
Special Library	0.00%	52.94%	47.06%

Figure 24: Primary Research Group 2014, 109

Table 18.3 Over the past three years what percentage of your digitization work would you say that you outsourced to third parties? Broken out by Type of Organization

Type of Organization	Mean	Median	Minimum	Maximum
College or University Library	33.44	22.50	0.00	100.00
Museum	1.67	0.50	0.00	5.00
Public Library	60.00	75.00	1.00	100.00
Special Library	31.41	5.00	0.00	100.00

Figure 25: Primary Research Group 2014, 114

With digitization work increasing, but outsourcing remaining a small part of museum practice, this may point to a growing workforce of people skilled in digitization. However, more data specifically about staff would be needed for such an assumption. Having acquisition done by skilled museum staff that are familiar with the artifacts would naturally be preferable, however outsourcing implies expert digitization technologies are used which is good for artifacts in the long-term as it reduces handling, and good for users as it implies quality results. Using my own case study as a source, though, there must be effective communication about the artifacts to be digitized. The museum staff will know more about an artifact, including what parts of the artifacts are the most important to get accurate information on. As previously explained in my case study, the application of color can have many different results. It is important for the museum to be able to describe exactly what places on the model are interesting or troublesome, so that they get the exact 3D model they need.

Table 14.3 Has your organization used any form of crowdsourcing to catalog, physically digitize, describe and label, or otherwise foster the digitization of your collections? Broken out by Type of Organization

Type of Organization	No Answer	Yes	No	No but we plan to use crowdsourcing soon
College or University Library	3.85%	11.54%	73.08%	11.54%
Museum	0.00%	26.67%	73.33%	0.00%
Public Library	0.00%	33.33%	55.56%	11.11%
Special Library	0.00%	11.76%	64.71%	23.53%

Figure 26: Primary Research Group 2014, 94

Crowdsourcing is an emerging field in museum practice. Though a small amount of museums have reported trying the practice themselves (Figure 26), there have been some very visible successes and failures, both examples of which have been performed by the Smithsonian Institute. Beginning with the cases that turned out

negatively, an exhibit on video games created some disturbance in the art and gaming communities. The show attempted to give the public a voice in the games that were included via an online vote from a list of games, however, many were vocally unimpressed with the games chosen (Kaganskiy 2011). This was perhaps just a symptom of the main problem though, which many thought was the crowdsourcing itself: "many felt that the populist voting approach was a bit of a cop out on the curator's part and reflected, for lack of a better term, a lack of conviction (ibid.)" When curators are perceived as abdicating some of their duty, the outcome is questionable. As Keene wrote in 1998, "…it is absolutely essential to their future in the digital world that museums continue to present themselves as purveyors of accurate and reliable information (1998, 26)." This is a lesson that none of the Smithsonian museums are likely to forget.

There are several examples of excellent outcomes for crowdsourcing from The Smithsonian Transcription Center. For having only been operational since July 2013 (https://transcription.si.edu/about), they were reporting numbers of 18,000 transcriptions done by 1,400 volunteers after just three months (Mckenzie 2013). Not only does the museum get help with a large volume of work, but it may teach people about the subject more effectively than the passive museum experience can. Biological research suggests that humans can learn more when being active participants and seeing results, as well as when learning with a group (Satwics 2011, 202)

As people become more familiar with digitization efforts, one does wonder if some cases of crowdsourcing 3D models might eventually turn up. Image-based 3D modeling software such as Agisoft PhotoScan is relatively inexpensive, especially when considered alongside other technologies, but it also has a user-friendly interface and straightforward process. This could be helpful for objects in public places, such as rune stones or public statues. These objects could be considered prime targets for crowdsourcing of 3D modeling because of their manageable size and relatively indelicate material.

Considering ethical principles, crowdsourcing could help create a more meaningful relationship between museum and community. As Graham Black put it:

> People today increasingly refuse to be passive recipients of whatever governments, companies or cultural institutions such as museums have to

> offer; instead they seek to be active members of what Scott McNealy (2005), chairman of Sun Microsystems, has declared to be 'the age of participation'. (2012, 5)

Museums might get more interaction from their audience if they expect and accept more diverse forms of cooperation than in the past. Visitors are no longer content with simply "visiting". Thinking of a community as a "visitor" or "audience" limits the ability of those people to act. Even if not through crowdsourcing, it is clear that for museums to be relevant in the future they must develop routes for patrons to become active participants in the museum's missions.

5.5: Long-Term Use and Results

Here I will discuss the long-term uses and other results of 3D modeling projects. While the acquisition may be temporary, the 3D model will be a museum resource for the foreseeable future. I have addressed several of these goals previously in the first section of this chapter (5.1: Beginning the process), and will not discuss them overly much here.

Beginning with the uses which result in revenues, Figures 27 and 28 illustrate how museums can use their resources very profitably. The Primary Research Group's 2014 report has been very informative for these points. As Figure 27 points out, over half of the museums surveyed have leased or rented part of their digitized holdings (139). This is a potential source of revenue, as Figure 28 (on the following page) shows the top value of surveyed museums made up to $500,000, though the averages are sharply lower. This is one of only two reported revenue streams I could find. The second can be seen in Figure 29 (on the following page). Only about a quarter of museums reported increased revenue of items related to the digitization efforts (op. cit., 144).

Table 23.3 Does the Division (s) license or rent use of any aspect of its digital collection to any party? Broken out by Type of Organization

Type of Organization	No Answer	Yes	No
College or University Library	11.54%	3.85%	84.62%
Museum	6.67%	53.33%	40.00%
Public Library	11.11%	22.22%	66.67%
Special Library	5.88%	17.65%	76.47%

Figure 27: Primary Research Group 2014, 139

Table 24.3 If the Division licenses, rents or sells any aspects of its digital collections, approximately how much revenue ($) did it accrue from these activities over the past three years? (A ballpark guess is sufficient if you don't have definite figures) Broken out by Type of Organization

Type of Organization	Mean	Median	Minimum	Maximum
Museum	80039.29	1200.00	0.00	500000.00
Public Library	200000.00	200000.00	0.00	400000.00
Special Library	13750.00	2500.00	0.00	50000.00

Figure 28: Primary Research Group 2014, 141

Table 25.3 Has the digitization of any of your collections led to higher sales of reproductions and items related to your collection through gift shops, catalogs or other venues? Broken out by Type of Organization

Type of Organization	No Answer	Yes	No	Not really applicable to us since we don't sell such items
College or University Library	15.38%	0.00%	15.38%	69.23%
Museum	13.33%	26.67%	33.33%	26.67%
Public Library	11.11%	0.00%	33.33%	55.56%
Special Library	5.88%	23.53%	29.41%	41.18%

Figure 29: Primary Research Group 2014, 144

The theoretical aspects of this section will be lasting. I have already spoken about several of the outcomes, as they were the goals and justifications that museums provided to begin the process. Some aspects of collections management, educational roles, and visitors' expectations will be re-addressed here.

Collections provide the material basis for museums' existence. Museums need materials in order to do their work, and because their materials are valuable non-renewable resources, caring for them is a top priority. Ideally, that is. Nancy Moses described how other priorities kept collections moving further down the list, and the questions she would ask herself: "how were they [museum directors] able to satisfy today's public and still preserve their treasures for posterity? (2008, 6)" Moses notes that this struggle was present throughout US museums (ibid.), and very likely still is. I have cited ICOM previously in this thesis, and they make it clear that museums have an ethical responsibility to take care of their objects. 3D modeling could help museums to find a balance. Once the model is created, it can be used to serve any mission statement. This multi-purpose tool is infinitely clone-able as long as you have space on the hard drive to store it. Curators can use the model for preservation,

education outreach coordinators for instruction, researchers for publications, and the list goes on. The benefits to collection, briefly, come in having a preserved model that can be visualized even after the artifact itself is gone, whatever the reason. Turning to the intersection of curators and users, it also significantly reduces the risk of unfamiliar people handling delicate objects.

3D models can help museums turn one-off visitors into long-term users. By engaging their communities at each step and allowing them to invest in the project, users become invested in the museum as a whole. Taking suggestions for what to digitize can help to democratize the process, removing the strong top-down approach that museums have so often relied on in the past. As an end product, 3D models can expand the reach of a museum's collection by removing the geographic restrictions on how far artifacts can travel. This allows the museum to send its knowledge to classrooms that otherwise could not make it to their physical premises. Mission statements and codes of ethics virtually always dictate that museums must actively distribute the knowledge they hold. 3D modeling can help both academics, and academics-in-training access artifacts and more complete information than can often be included in an exhibit setting. The removal of geographic location as a barrier is an undeniable advantage that is specific to this technology.

This geographic aspect has not been *as* useful as once thought, however. Going back to the 2004 report from the Institute for Museum and Library Services, over 25% of museums in 2001 reported that one of the goals for their digitization efforts was to "Encourage cooperation among institutions to increase the number and variety of materials available (2004, 37)". This does not appear to have manifested yet in 3D modeling. Of the 5 online databases containing 3D models that I found in my search, only one database was multi-institutional. That database held information from 5 institutions in Great Britain, 3 of which are museums. While there is certainly some alleviation of geographic range in this example, it is not the expansive distance that one might imagine when first conceptualizing the possibility.

Overall, the end product is a multi-purpose 3D model for museums to employ in a variety of ways. I hope to have enabled this for Blekinge Museum. The product in itself does not have any glaring ethical quandaries. The main point is to have museums understand their mission statements, and employ them wisely.

5.6: Overarching Problems

As private individuals and consumers, many of us have become impatient about delays when it comes to our information needs in any area of our lives. Museums, in general, have not yet responded to this demand for information at the touch of a button. But the time is coming when this will be the expectation rather than the exception.

Jones-Garmil 1997, 59

Jones-Garmil wrote the above quote in a 1997 publication, though it is certainly applicable to the situation today. Ross Parry has expressed the sentiment numerous times that we are asking many of the same questions as we were about digitization and accessibility almost 50 years ago (2007, 1). Standardization, integration, and user behavior are all frequently addressed subjects within digitization.

In the northeast US, Harvard is active in trying to integrate libraries, archives and museums (LAM) into the same database. Some of the obstacles quoted are familiar to those studying digitization efforts: "the lack of interdisciplinary standards for organizing collections, the geographic distance typically separating LAM collections, and interdisciplinary rivalries about which agency should take precedence (Leddy 2012)" all contribute to the obstruction of integration. Standards are a particular problem in this area of study, as 3D models generally do not have to meet any technical standards. If they work for the purpose they were created for, they are acceptable. It is my belief that having no set standard or definition will impede future efforts at integrating databases from multiple institutions. Guy Herman astutely pointed out in 1997 that: "In a connected world, a non-standard information source will be an unconnected information source (72)." Delaying our arrival at a standard only pushes our ability to interconnect institutions further into the future. Again, Guy Herman: "We need them because standards enable cooperation, communication, and information exchange. Perhaps most important, they protect the long-term value of our information. (op. cit., 71)". When looking at the one multi-institutional database from some institutions in Great Britain, the website actually includes the following disclaimer about how the data is presented from each institution: "Each use their own standards, and when combined may produce some inconsistencies (GB3D website)".

User behavior in terms of databases is also still a point of difficulty. Ross Parry pointed out that in the beginnings of museum computerization, curators and the public often used different categories or terminologies to search (2007, 26). The concern over how non-staffers use databases is still present: "We need to focus on user behavior. We don't know enough about how they use resources," he said, but "users expect to be able to span the scope of knowledge in seconds. (Leddy 2012)"

Democratization of the museums process can be great for public participation. However, a more democratic museum process should not necessarily be considered an ethical improvement. While it is important to take input from constituents, professional knowledge and experience cannot be replaced. This can tie back to the internal narrative of Nancy Moses mentioned previously. For example, when deciding what artifacts are a priority for 3D acquisition, it may be unlikely that users have the best interests of the collection in mind when they want something digitized. Curators are intimately familiar with the very real, very practical needs of the collection, and have the ethical upper hand when it comes to the need for their collection's survival. However, a museum cannot neglect the interest of their community. The ethical dilemma is still prevalent, even if democratization is encouraged.

Chapter 4: Conclusion

"New" is not necessarily better or even good. "New" may be superficial and ephemeral, or even turn bad and greedy, if the aim is not to get to the bottom of things, getting things into place both at the surface and at deeper institutional layers.

Svanberg 2010, 27

3D modeling can help museums meet their ethical responsibilities to their public and to their collections. In order to get the most out of this process, museums must have a good understanding at the outset about their own mission statements, or in the words of Graham Black, what they are for (2012, 5), and what they do (Stiff 2010, 355). "You have to ask the question if this furthers our mission, and it does," said Waibel (Jarvis 2013). I agree.

3D modeling can help museums with museum goals both in product and in process. When an audience is reached outside the museum's walls it can help turn visitors into users, and perhaps even into investors. The goals that 3D modeling help museums accomplish are important and numerous. However, this must not blind us to the theoretical implications and quandaries that it also brings.

The technical methodology is not something that I attempt to put on trial here. The methodology itself has been thoroughly discussed even as it continues to develop. What I have attempted to do is bring a theoretical assessment to the practice itself, regardless of the instrument or technology used. Theoretical discussions around digitization as a whole have been distinctly lacking compared to the more practical matters. Ross Parry wrote in 2007:

> Maybe, until now, we have been too close, too much in the moment itself, to take our vantage point as the historian looking back meaningfully on what has happened. The irony is, of course, that the further away we come from the historical period on which we are writing, the more dislocated we are from that moment, from that locality, and the harder it becomes to appreciate the pressures and the personalities that may or may not have affected events. (7)

Many institutions are aiming to increase their digitization and 3D modeling efforts. Now is the time to discuss, disagree, and debate through the ethical ramifications within museum and archaeological practice.

Continuing through the process, museums should engage and converse with the public at every step possible, taking good suggestions when they're given, but while also holding on to professional ethics. As demonstrated with crowdsourcing, curation is an irreplaceable skill. The judgment of museum professionals is expected and appreciated. Though, that should not mean that anyone's judgement is above questioning and discussion, especially with issues such as cultural heritage.

Previous publications much more often focus on the technical over the theoretical. In some places, it is difficult to begin a theoretical conversation because the label as a "tool" limits the understanding of our effects on technology's development, and its equal effect on us. I believe that this has had an adverse effect on some stages of this process. For example, underreporting of the criteria used for prioritization has left so little data available that beginning a discussion is difficult, aside from the somewhat alarmist terms of underrepresentation of cultural heritage.

Representation is a problem in prioritization, but also in product. There is a possibility of creating a 3D model presence that is un-representative of the cultural heritage of museum holdings, and of the available world heritage artifacts in general. But how to communicate the representation of artifacts themselves must also be discussed in this setting. Though I have spoken about this already in my case study, the 3D model is a representation of an artifact, interpreted by a professional. This should not be considered a perfect clone of the artifact reality as much is left to the professional to construct. In order to hold on to authority, it is up to the museum to make sure their community understands 3D models in terms of authenticity. As Neil Silberman wrote, "both the nature of authenticity and the role of interpretation are being re-examined and redefined. (Kalay 2008, 89)" The museum needs to communicate what a "model" means, and why it can be labeled accurate. A 3D model is not exactly the same as the artifact, but an academically honest representation.

As I have mentioned in my source-criticisms from the same section, conservation could be the most effective use museums have for this technology at this time. Though incorporeally, 3D modeling can help preserve an artifact's appearance through many varieties of physical catastrophe. However, it cannot completely preserve all physical qualities, such as weight and sharpness. Additionally, any

unnoticed detail may not make it into the final model if more intensive reconstruction needs to be done on the mesh.

Museums must consider the entire chaîne-opératoire as an opportunity to extend their mission statements. To use this type of project in the most effective manner, each step should have a connection to the museum's community. From considering their desires for accessible information, to including them in funding and prioritization, perhaps even acquisition, and then inviting them to use the product, museums can get much more out of this process than 3D models. If each step is used to its fullest extent, this can create a community that is both informed about the artifacts and their representations; but also invested in the museum's future, as well as its artifacts of the past.

Summary

To acquire and maintain a collection using the best practices available is the responsibility of the present. Especially for future research, preserving materials in their present state and making them more accessible is paramount. These two objectives, and many others, that be accomplished through a thoroughly-applied 3D methodology.

A museum is not only beholden to its collections, but to its public. Often, the desires of Curators for the safety and preservation of artifacts is at the odds of the public's desire to view the artifacts, as well as the museum's mission statement to expand knowledge using its collection. 3D modeling can bridge this gap, making representations easily accessible to the public, even over long distances, while not putting the one-of-a-kind finds in a position to be physically damaged.

The representation must still be communicated to be just that – not a digital replica, but an informed and trustworthy interpretation. If museums do not entrust this knowledge to their audience, they run the risk of loosing credibility both in the virtual and real world. Museums could also loose credibility through their prioritization decisions. Should their 3D models not be representative of the cultures in their holdings, they need to be prepared to justify this decision.

In summary, 3D modeling does fit with museum mission statements, ethics, and responsibilities. 3D modeling does not just create 3D models, it creates opportunities for museums to have sustained conversations with their visitors, and turn them into an invested audience. It increases the "ethics of deployment (Hein 2000, xii)" by increasing effectiveness of a collection, making it available when the public's request, not museum opening hours. It can create opportunities for more research about their holdings, and more inquiries both by public and academic interests, supporting their responsibility of public education. And in terms of ethics, it can help them preserve their collection through any number of accidents or losses. However, these outcomes can only happen if they open up the chaîne-opératoire to more public input, not just in the product.

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Natural History Museum, London, England: http://www.nhm.ac.uk/nature-online/life/dinosaurs-other-extinct-creatures/dino-directory/index.html

Smithsonian Institute, Washington D.C., USA: http://3d.si.edu/