Responsible Recording of Historic Sites and Buildings Based on Skills, Training and Sound Judgment

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Abstract
It has always been important for the field of Preservation to collect data as a means for understanding the past or present of a particular site, and to comprehend how that data will be used as a mechanism for future understanding and interpretation of the site. There is a place for technology and preservation recording to work together, however the field must take steps to properly educate its graduates and professionals in understanding the benefits and limitations of each, and allowing them to answer the question that preservationists must ask: Is the selected technique for recording justifiable? Are the people doing the work qualified? How can the product of that work justify the cost? And does the resulting work have any longevity? All good decisions for recording should first address the issue of need. Unfortunately, the use of expensive tools is harder to accept when the budgets associated with projects are tight as they are in preservation. Lack of knowledge though is the principle driving force for why these tools have been vilified by some in preservation, while praised by others. Without clearly defined tools, capture methods, resolution standards, file types and necessary final deliverables, understood by both the provider and user, the gap of knowledge in proper recording tools and methods will continue to widen.

Keywords
NPS, AIA, certification, registration, requirements

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RESPONSIBLE RECORDING OF HISTORIC SITES AND BUILDINGS BASED ON SKILLS, TRAINING AND SOUND JUDGMENT

Matthew Robert Morgan

A THESIS

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TO MY FAMILY AND FRIENDS.
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CHAPTER 1: INTRODUCTION

It has always been important for the field of Preservation to collect data as a means for understanding the past or present of a particular site, and to comprehend how that data will be used as a mechanism for future understanding and interpretation of the site. The goal of this thesis is to create an objective evaluation that will enable future preservation professionals to make sound judgments and selections of available recording techniques that will include both “simple” and “complex” options. There is a place for technology and preservation recording to work together, however the field must take steps to properly educate its graduates and professionals in understanding the benefits and limitations of each, and allowing them to answer the question that preservationists must ask: Is the selected technique for recording justifiable? Are the people doing the work qualified? How can the product of that work justify the cost? And does the resulting work have any longevity? All good decisions for recording should first address the issue of need. The field of Historic Preservation has been demonstrating a keen interest in “modern” or “high-tech” tools, borrowing from other industries such as, oil, film and automotive, just to name a few. These industries, which are both well established, and well financed, are usually able to illustrate a justifiable link between the capture process and the final product in order to justify the high costs. Unfortunately, the use of these tools is harder to accept when the budgets associated with projects are tight as they are in preservation. Lack of knowledge though is the principle driving force for why these tools have been vilified by some in preservation, while praised by others. The result is a gap in both capturing data and final product, driven by a lack of knowledge from both the user and provider alike. Without clearly defined tools, capture methods, resolution standards, file types and necessary final deliverables, understood by both sides, this gap will continue to widen.
Given the exponential rise in available documentation technologies in the United States and abroad, driven primarily by digital tool manufacturers and organizations that promote their use, it has become critical that the field of Historic Preservation reevaluate its approach to recording structures. This is imperative in the digital age where new technology is often seen as a “black box”\(^1\) solution often functioning more as a replacement than a compliment to traditional recording tools and techniques. Accurate site recording plays a pivotal role in the interpretation, conservation, and preservation of our historic sites; from small-scale houses to large landscapes, with each site presenting a unique set of challenges. As critical as the recording of a site is to any project, the jobs of the individuals who execute that work are not clearly defined and the type of training needed to execute the work properly is not always understood. While the recording methods of the past, like field sketching and basic photography, were simpler to identify and understand, having become standard methods for capturing field information in related fields like architecture, the expectations of professionals in the field have expanded, as has the arsenal of tools available for recording. What may have initially involved a basic tape measure and pencil, can now involve complex tools such as total stations (FIGURE 1), laser scanners (FIGURE 2) and three-dimensional (3D) modeling software, all of which require specialized training to operate.

The ability to operate these tools cannot be the only function that defines the job of the “site-recorder,” since much of the recording process involves organizing, and synthesizing the created data that these instruments produce. Clearly, the end goal of data collection is to create a usable and “useful” product for a site manager, conservator, or an architect. Depending on the

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1 “Black box” refers to “a device, system or object which can be viewed in terms of its input, output and transfer characteristics without any knowledge of its internal workings.” (Definition from Wikipedia- [http://en.wikipedia.org/wiki/Black_box](http://en.wikipedia.org/wiki/Black_box) Accessed May 13, 2014.)
objectives of the recording, different disciplines may each require a different product to suit their research needs, and each of these products may need to be created from common data. For example, the conservator may approach recording of a site through the lens of ensuring that the site is recorded in a way that will place more emphasis on material integrity of the building, whereas the historian may look to the recording to tell a much deeper story about the people that used the site. As such, a thorough understanding of the available tools, the software to manipulate the data, the training required to operate these tools, the long-term stability of the resulting data, and the associated costs of operation and maintenance is critical. Although site recorders may collect their data in only a few sessions, the resulting data will live long past this initial recording and must be stable and flexible for future analysis. Careful, thoughtful, and accurate recording must be undertaken at all times by the site recorder.

In the field of Historic Preservation, the focus has been on obtaining processed data in order to execute work, such as conservation plans or site reports, often with limited knowledge as to how the raw data is obtained and/or processed, or the associated training and costs. A large amount of literature is focused on the final results of projects while a much smaller amount appears to reference the associated costs of the equipment, training, and post-processing of the data, or the limitations of these new technologies. While extensive amounts of literature have been written about both the methods, as well as the products produced in the recording arena; like literature associated with many fields of investigation, the articles which outline the drawbacks are often very difficult to find. Since few ever want to make light of a project that was not entirely successful, this imbalance should not be automatically correlated with failures though. Since both failure and success work hand in hand to help define limits, this unfortunate lack of literature can rob these investigative fields of valuable lessons for the future.
This thesis will first look at HABS, which is a well-established organization with a long tradition of recording within the heritage field, and which serves as a model for how historic architectural recording has been, and continues to be undertaken in the United States. This section will address the pros and cons of a standardized format for which HABS requires submission into the Library of Congress for archival storage. This section will also discuss the various documents that make up a HABS submission, from field notes and measurements, photography, measured drawings, and the requirements placed on each method. This assessment is meant to illustrate that the HABS guidelines are fundamentally for setting standards of submission, rather than of recording. The intent of this research is to open up a wider conversation as to the evolution of recording techniques from 1933, when HABS was first established, which will allow for the analysis of current methods of recording, particularly regarding the role of digital technology.

From there the analysis will move to a critical review of the current literature available on the topic, both peer reviewed, as well as industry literature, which can be disguised as objective but often serves as promotional material. Recent scholarship tends to cover over a lack of understanding and appreciation within the field of Historic Preservation as to the overall costs of data capture, equipment, and training required for some of the newer recording techniques, while at the same time highlighting the rapid encroachment by companies promoting high-tech solutions for recording our historic sites. Companies promoting these solutions can often suggest value under a veil of ease-of-use, and razor-thin accuracy in promoting their products, without disclosing the cost and complexities of achieving these results. Although there is baseline knowledge as to the capabilities of these technologies, understanding where and why these tools should be used can be a mystery to many users. This
commentary is not in any way meant to reject or discourage the use of new technology for recording, but instead to highlight the complexity of these techniques.

The focus will then shift to the ways in which data is collected, migrated, and stored for simple tools as well as and complex tools\(^2\). Understanding the flow of information from capture, processing, and dissemination is key to selecting the right technique for the job; weather conditions, travel, space requirements, etc. can also dictate the selection, and will therefore be discussed. This thesis will discuss a range of technologies available for recording, from analog to digital, paying particular attention to the benefits and limitations of each, as well as looking to other professional fields and their requirements for illustrating expertise. Through a thorough understanding of the challenges facing site recorders, the preservation field will be able to make better-informed decisions as to the appropriate level of recording required for their specific project.

Next, this thesis will discuss the importance and function of certification by looking to other fields, which have certification requirements to demonstrate competency. Architects, Engineers, and Surveyors all go through rigorous amounts of formal training, and ultimately must past a set number of exams, prior to professional certification or licensing. This certification process seeks to establish safety for the user, as well as a trust between the user and provider. The field of Historic Preservation does not have such standards in place to illustrate competency in the field of recording, which allows anyone to claim they are qualified.

To complete the inquiry started in this paper, analysis will look at some of the costs associated with recording techniques. If the field of Preservation is going to pursue the use of digital technology in the future, it must analyze the cost of these tools and techniques. As

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\(^2\) The idea of “simple” and “complex” in this thesis is explained in depth in Chapter 4.
budgets for recording historic sites and structures continue to decline, site-recorders as well as preservationists in general, have a responsibility to make well-informed decisions as to the means and methods used in order to ensure that they are being as efficient as possible and providing appropriate services to the user.
CHAPTER 2: HISTORY

WHY RECORD?

Our architectural heritage sites are constantly under pressure from re-development and environmental factors. As Charles Peterson stated in 1933 “our architectural heritage of buildings... diminishes daily at an alarming rate.”3 As much as some would like to believe, not all buildings deserve to remain a physical presence on the landscape. However, maintaining a record of them for future generations to learn from and study is critical. Site recording, and documentation function as the collection system for historic structures and sites for the associated fields of heritage management in the United States, and the Historical American Building Survey (HABS) has served as the baseline for that system. But while HABS dictates the requirements of the final product, it leaves much of the recording process up to the site-recorders.

BACKGROUND

In 1933, Charles Peterson proposed the creation of the Historical American Building Survey to act as an entity within the National Park Service that would document America’s architectural heritage.4 Peterson, a National Park Service employee, was quite the visionary; recognizing the great importance that recording our built heritage could play in the telling of our history, and understanding the harsh reality that only a small percentage of structures might survive. He provided initial selection criteria for buildings “worth” recording, covering a wide range of building types from “public buildings, churches, residences, bridges, forts, barns, mills,

shops, and rural outbuildings...”⁵ A key advantage for documentation during the early days of HABS was the availability of unemployed architects to carry out the recording. Peterson realized the value of unemployed architects and draftsmen because they had the proper skills and training necessary to perform the job well as a result of their formal education. Skills and training are the important words here because architectural education and training at this time would have provided individuals with similar base knowledge or “skills,”⁶ helping to ensure consistent methods for recording. Presumably, standard methods would result in standard products, and the long track record of HABS has confirmed that assumption.

THE IMPORTANCE OF GUIDELINES

From its inception, HABS recognized the importance of utilizing a consistent set of guidelines and methods for recording, all of which were based on a traditional architectural language, and the existing skills and training of unemployed architects were the basis of these systems. “Throughout its history, HABS has had consistent standards concerning the size, format, and reproducibility of documentation.”⁷ This is not to say that there is not flexibility in how one records historic sites and structures, as each project provides a unique set of challenges, but following some guideline was and still is critical. The most important reason for standardization is readability. The drawing systems employed by architects are a language, and all who learn this language can read the product. One of the most critical reasons for consistency is the ability for future recorders to “re-check” previous work for accuracy, and

⁵ Recording Historic Structures, 3.
⁶ Skill is defined as “a craft trade or job requiring manual dexterity or special training in which a person has competence and experience.” (http://dictionary.reference.com/browse/skill) Accessed May 13, 2014).
correct any potential errors made in the initial recording phase. Following the guidelines ensures that each project will produce consistent results.

**HABS PRODUCT**

Until recently, resources for recording sites and buildings had changed very little in the 81 years since HABS formed. Buildings are often recorded using simple tools such as a tape measure, pen, paper, and cameras, and executed by small teams of novice recorders such as volunteers and students. These teams are led by someone with the “skills and training,” such as an architect, to ensure consistent results. In recent years, through more technically advanced systems, such as laser scanners and total stations have entered into the tools HABS uses to record structures, but with some trepidation.

Measured drawings form the foundation of recording the buildings within the HABS collection, and they “follow standard drafting conventions to portray a three-dimensional structure or site in two dimensions,” through plan, section, and elevation. Created from the conscious act of hand sketched field notes created by the site-recorders, these field notes are an essential part of the site recording process, and diligence must be taken to ensure accuracy for the final drawings. “HABS measured drawings are accurate, detailed, scale drawings that portray and interpret the significant features of the recorded structure in a standardized format on an archival stable medium.” Several drawings make up the drawing set, each of which contributes to the overall set by displaying different characteristics and elements of the building or site, from the very large to the very small. While plans, sections and elevations communicate three-dimensional information, they are truly two-dimensional drawings.

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8 *Recording Historic Structures*, 88.
9 Ibid.
An architectural plan refers to “a two-dimensional graphic representation of the design horizontal dimensions of the building, and location, as seen in a horizontal plane view from above.”

The architectural section is “a representation of an object as it would appear if cut by an imaginary plane, showing internal structure.” The architectural elevation represents “a drawing showing the vertical elements of a building, either exterior or interior, as a direct projection to a vertical plane.”

The plan allows the user the ability to understand the spatial layout of the site or building including stairs, rooms, as well as informing the user about the horizontal circulation of the space. The plan, typically cut at the windowsill height, allows the user to identify openings such as windows and doors. The plan does an excellent job of expressing the overall layout, but lacks the vertical element that the section provides. The section operates much like the plan in presenting stairs, location, wall thickness, but adds the important factor of how the building works in the vertical circulation. A key difference between a section and a plan is that the plan is much simpler in that it does not require much thought as to where one would cut it. Simply put, a cut can be made right above the windowsill, or moved up a foot and cut through again, and the information gained or lost does not vary significantly. However, cutting a section through a building is a conscious act executed by a trained draftsperson, enhancing the significant features through the proper selection of the section-cut.

The goal of the section is to get the most information about the building with one cut. The elevation, either interior or exterior, tells the story of the finishes used on the structure, from siding to columns and corbels.

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Although not a requirement for submission to HABS, additional drawings may be included, such as an axonometric drawing\(^{13}\), further demonstrating key features of the construction such as framing techniques. All of these different types of drawings, working in conjunction with each other, tell the complete story as best as possible and it is only through good skills and training that this story can be told well.

**PHOTOGRAPHY**

HABS maintains very specific requirements for the production of archival quality photography by requiring the use of large-format cameras. “Large format is defined by HABS as photography using cameras that produce 4" x 5", 5" x 7", or 8" x 10" negatives. The program’s staff photographers currently use 5" x 7", which seems to have been the most popular format since the founding of HABS in 1933.”\(^{14}\) This format requires skills and training with the camera and knowledge of how to create the required shots. As well as the eye of the photographer, the photographs must be in black and white-as colored photographs are not as stable. Once the HABS photographic documentation is complete, the negatives and contact prints are chemically treated for storage. The negatives are washed to remove all of the processing chemicals that were used to develop them. HABS requires that the “negatives and contact prints will last at least 100 years.”\(^{15}\) This work must be done by someone with the appropriate skills and training to ensure these photographs and negatives achieve this archival stability.

**ARCHIVAL STABILITY OF DOCUMENTS**

HABS fundamentally dictates the outcome of the product only, leaving the methodology to the individual recorder. Nowhere in the “HABS Guidelines” does it indicate a specific method

\(^{13}\) Axonometric drawing is a parallel projection, to illustrate an object in three-dimensions


\(^{15}\) Ibid.
for capturing the information required to produce a drawing set, instead using suggestive words like “should.” This differs from the wording used for creating the final product through where instructions are more direct. As in section 4.7.1 of the HABS guidelines where it states that “no poche is shown in wall and floors cut in section,”\textsuperscript{16} or section 5.7.1 where “each individual drawing on a sheet must be labeled with a title and notation of the scale.”\textsuperscript{17} The final products for HABS projects are produced with the goal of achieving a 500-year service life, exercising caution when implementing new technologies for recording until it is certain they meet the program standards for accuracy, verifiability, ease of reproduction, and archival stability. HABS has performance standards, and the products, or formal documentation, are “hand inked or laser plotted measured drawings; large-format film negatives in print; and transcript histories.”\textsuperscript{18} “The original drawings are currently prepared with archival ink on polyester sheets or plotted with laser or electrostatic plotters on polyester sheets for archival permanence.”\textsuperscript{19} Products must meet the requirements for HABS prior to submission to the Library of Congress, resulting in physical materials as the result, and the guidelines make that unquestionably clear with such guidelines as 5.9.3 stating that “final plots must be made on 4 mil (.004”) thick drafting film, also known as mylar.”\textsuperscript{20}

What is often overlooked in the history of HABS is that the original employees for HABS work were unemployed architects that had an already established set of “skills and training” to properly capture the data as well as the “skills and training” to turn those measurements into

\textsuperscript{17} "Recording Historic Structures and Sites with Habs Measured Drawings," (Washington DC: United States Department of the Interior, 2008), 16.
\textsuperscript{19} Recording Historic Structures, 13.
\textsuperscript{20} Survey, "Recording Historic Structures and Sites with Habs Measured Drawings," 20.
final drawings. These “skills and training” assumed that an architect or draftsman would know how to properly use a tape measure, which is good if the architects are the ones actually using the tools and the tools in question remain part of a traditional set of tools associated with that trade. But where do the total station and laser scanner fit into this format? Since putting tools into the hand of a novice cannot insure good results, unless there is someone with the proper “skills and training” to assist, it would be difficult to know for sure.

HABS IN THE DIGITAL AGE

According to a recent conversation with a current HABS photographer, Joe Elliott, it is inevitable that HABS will eventually implement more digital media into its archives. As the cost to develop black and white large format film prints becomes more and more expensive, fewer places offer this service. HABS has always approached new technologies with caution however, keeping in mind that it does create “…risks because it relies on complex hardware and software to store and retrieve data.”21 History has consistently shown that a paradigm shift will always force change even against strong resistance. The speed with which new technologies are evolving is incredible, making computer hardware and software obsolete in a short period of time and HABS is very wise to be cautious. Care must be taken to ensure file formats can migrate easily into the future. This rapidly evolving computer technology often changes faster than critical data can be migrated or archived, and working with the proper knowledge is key to success. Careful analysis by the users of computer-generated products must consider the original source material, including the conventions used in its production, its reliability and accuracy, and the relevance to the project. The computer does not discriminate between good or bad data, but many people are complacent in allowing the computer to differentiate because

the user often trusts the computer will only give good data. Unfortunately, in the current digital world, most people are far too trusting of computer-generated products. They are too trusting that the data entered into a computer are accurate, as if the computer process certifies or enhances the original. However, nothing could be further from the truth. The problem of faulty data is often referred to by the simple acronym of G.I. G.O., for ‘garbage in, garbage out.’ Computer generated historical data is no better or worse than any other historical data. It is important to be somewhat skeptical of new technologies until proven reliable.

**ARCHIVAL STABILITY, MIGRATION AND STORAGE OF DIGITAL MEDIA**

It took HABS until the mid-1980s to create a standard for collecting in CAD software, which was around the same time other organizations, such as the AIA, were doing the same. But the archival stability and migration of digital data continues to be a serious issue for HABS, and must be addressed prior to widespread reliance on digital systems for recording. The HABS system is the result of a marriage between three different organizations, each taking the lead on the part of heritage recording and storage that relates to them. The National Park Service is the organization that dictates the value of our cultural heritage, hiring people who specialize in the study, investigation and management/maintenance of historic sites and structures. The American Institute of Architects (AIA) works as a second equal partner and ultimately has responsibility for the language of recording building sites and structures. They have been the leading voice nationally for drawing standards and serve to ensure consistency in the visualization. And finally the Library of Congress act as the authority in archiving this important information. From each of the three institutions there are people with the “skills and training” critical for the success of HABS. A huge advantage to the current HABS requirements is that the

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22 Ibid.
final products come as paper documents, which do not require computers or special software to access and use, are archivally stable. HABS current system of archiving drawings in the Library of Congress is based on a standard set forth by the Library itself and not HABS. While HABS is responsible for ensuring the proper architectural formatting, each work being carefully reviewed by the employees of HABS who have been properly trained in the architectural language, it is the Library that has defined the paper and ink type. In this case, anything that relates to “archivability” is assessed and enforced by people properly trained in the skills of archiving. Recent digital developments have forced the system to look at the possibility of digital recording and storage. While the use of acid free paper and inks has ensured the longevity of these recordings, the use of digital formats has allowed for easy access by the public, and yet the uncertain future of digital formats in the minds of all parties. The current digital format is bitmapped since most of the data comes from scanned paper drawings, but more and more the drawing process utilizes modern digital systems where vector lines are the norm. Vector files are smaller and offer better, clearer display of the end products is therefore best retained in vector formats, and yet no standard for vector has been adopted for web-based dissemination. The migration of data into the HABS product remains a key concern facing HABS, as these products must have the ability to function well into the future. Careful consideration must be taken to ensure that implementation of the newest technique, such as laser scanning, does so in a way that makes the data available in the future. A major consequence of this would be the inability of newer systems and software to read previously recorded data, rendering it useless.

As far as HABS is concerned, their current CAD standard requires that “… the data must be gathered and entered with care to avoid impairing the accuracy of the results. An operator must have a firm grasp of geometry, understand optics and photographic techniques and
technologies, and possess a working knowledge of computer-aided drafting. All of which require a new set of skills and training and yet the understanding first set forth by HABS concerning skill, is not being necessarily reflected with modern recorders at a time when even the future of CAD is in question. If an operator of a software is not properly trained, serious errors can occur, and unless someone with the proper training and expertise oversees the work to verify the correct data, it may be difficult to locate or correct such errors.

Laser scanners often produce large quantities of data, creating extremely large files, and storage of this data must be considered. The argument is often that storage space continually grows, creating the illusion this will not be a problem; however, this does present a major problem in terms of access to this data. Large files require powerful machines and software to open and efficiently use, and great care must be taken to ensure that this data is easily accessible to the general public. Additionally, not all smaller organizations have access to digital storage for large files and may only have minimal space on hard drives or servers. The current format for HABS dissemination of materials to the public through the web uses the bitmap format. HABS takes the final product documents and scans them for distribution to the public. This bitmap format creates a pixel based product, which may render it less desirable in the future, as vector formats such as PDFs create higher quality results.

The Historical American Building Survey (HABS) serves as a baseline example of successfully documenting our historic sites and buildings, focusing on final product versus process. While more emphasis should be placed on the process leading to the final product in order to select the most appropriate tools and techniques in order to minimize errors in the final product, it would be very difficult to implement and almost impossible to police. HABS faces the

\[^{23}\text{Recording Historic Structures, 21.}\]
high-technology dilemma that other organizations in the field of Historic Preservation recording face, and have started utilizing many of the digital technologies, such as laser-scanners and total stations as supplemental tools for their own in-house recording projects, putting themselves in the same precarious place as others recorders in the field, while at the same time placing them in the awkward position of acquiring large quantities of digital data with an uncertain future.
CHAPTER 3: LITERATURE REVIEW

The literature review carried out for this thesis looked at a wide range of different sources. While books were a vital resource, the biggest resource for determining the current trends was periodicals. While peer reviewed articles were used, included in the survey were articles taken from trade periodicals such as Point of Beginning (POB). Industry professionals in the field of Surveying, many who actively work for the companies that sell the equipment, training and resources. write these articles were used to assess the voice of the industry. Where digital technology is concerned, the review of the literature concerning recording of historic sites and buildings suggests a trend moving away from traditional analog tools and training such as tape measures and field sketching and towards digital recording, which includes laser scanners and total stations. Although more prevalent in the writing of the non-peer reviewed material, in all cases the trend suggests that providers who utilize the newer technology can muster support for that technology from users through careful emphasis on the benefits of the tools and products. Unfortunately, one of the ways of doing this is to overlook key issues of high costs, while placing strong emphasis on visualization results, that are often not a final product. Users will often absorb this biased perspective, thereby placing themselves in a secondary role within the recording process. In addition, the literature shows that a gap exists in the user / providers relationship which does not address the difficulty to understand what the actual final product needs to be or how that product can be produced. This information gap, created by lack of knowledge on the part of both users and providers alike, could place the future of site recording on a dangerous and slippery slope, where process is rarely understood, product is often never achieved, and high costs are limiting the potential for good quality recording.
INFORMATION PROVIDERS AND INFORMATION USERS

For the purposes of this literature review, the key players have been separated into two categories consisting of the information provider and the information user. The information providers consist of laser scanning companies, photographers, surveyors, engineers and architects that provide recording services such as laser scan data, photography, land surveys, structural analysis, and as-built drawings. Information users refer to any individuals or organizations that receive the recording services from the information providers.

While the push by reputable providers is fundamentally to use the best tool for the job, some providers may choose to use modern technology based less on whether the selected method is the most appropriate and cost effective to the user, and more as a means to promote themselves and make money. These providers can suggest to the user that laser scanning reduces “both the costs and the risks associated with site work,” and some companies believe that “heritage professionals are likely to be more interested in having an accurate drawing on which to base their specification of works than in the process behind it.” If this statement is in fact true, then users are frequently uninformed about what is involved with creating a final product, leading them to believe that laser scanning produces perfectly captured data easily and cost effectively. Unfortunately, no single system can provide the perfect solution.

Many just entering the field of historic preservation are ignorant of the complexities of recording. In 2012, a graduate student in historic preservation at the University of Florida stated, “one of the main benefits of the scanner is that it is both accurate and fast. With this scanner, one room can be documented in mere minutes, rather than documenting by hand,

25 Ibid.
which could take hours.”26 While this statement has some truth behind it, a statement such as this highlights a lack of comprehension students have in regards to the complexity of technology and recording as a whole. While the scanner may capture data quickly, it is “raw” data that can require extensive post processing using complex expensive softwares to arrive at a usable product. Post processing can easily take more time and money than would be required to record a single room in the field using more traditional methods. The “scanning because we can” mentality can often replace sound and responsible decisions made by recorders, who choose to think for themselves instead of allowing the technology to do the thinking for them. History has shown that the more common systems of recording dissemination such as plan, section, and elevation have been, and will continue to be of critical importance to most trades associated with the building industries. While architects have begun to work towards implementing three-dimensional drawings as a means to create a digital file, these files will continue to be printed and carried to site as a plan, section, or elevation. If in fact the common systems of traditional architectural dissemination will continue to hold a place of importance, what does it take for a three dimensional digital file of points in space to become two-dimensional drawings? For a raw laser scan file to become a traditional line drawing, this requires a multiple step approach, where the raw scanner data known as the point cloud first must be converted into a mesh.

“To convert from a point cloud to a mesh is a simple process that many softwares can do, including freewares like Meshlab. In the case of three-dimensional drawings though, the gap between a poly-mesh and a typical three-dimension CAD file, commonly referred to as a NURBS (FIGURE 7) models, is much greater. A Non-Uniform Rational Basis Spline (NURBS) is a mathematical model commonly used in computer graphics for generating and representing curves and surfaces. Polymeshes are composed of a large number of points connected with a series of straight lines, where curves are implied through dense faceting in the same way that rigid tiles on a contoured roof appear to curve. Softwares such as Maya, Solidworks and GeoMagic, that deal with point clouds

or meshing, use raw scanner data as a basic form in order to “reverse engineer” a three dimensional final drawing composed of NURBS, which in most cases is a simplification.\(^{27}\)

These curves and surfaces are based on a ‘best fit’ form, made up of down cycled data down cycled, and the created lines are not “necessarily placed along the edges of clearly defined shapes as would be seen in a two dimensional ‘outline’ drawing.”\(^{28}\) The belief that capturing data using digital technology is a quick solution to recording is simply based on a false understanding of the time requirements and multiple conversion softwares that must be used after the scanning takes place. Complex tools do not provide a “magic button” one pushes for the production of recording drawings, and given that “the point cloud might typically contain between one and ten billion points,”\(^{29}\) the time to convert this data must factor into the discussion. Through a discussion with one laser scanning company at the APT conference in New York City 2013, the salesman stated that post processing time to convert the data from the point cloud could takes as much as 9 months depending on the complexity of the original file.\(^{30}\)

Buildings and sites will always deteriorate over time, either by exposure to the elements, natural disasters, or human destruction and laser scanning does not impact or change this fact in any way. What has become a trend to support the scanning process in relation to heritage sites though is the argument that scanning can “preserve” our heritage sites for the


\(^{28}\) Ibid, 38.

\(^{29}\) Miller, "Laser Scanning- Surveying, Recording and Monitoring Historic Buildings".

future. In an online article, the director of CyArk is quoted as saying “while there isn’t enough
time or money to save all these sites physically, we have the technology to digitally preserve
them... and by doing so, we will ensure that these treasures are available for appreciation and
study for years to come.” Although true, this statement fails to underscore the more
significant issues, which are the cost associated with the process, the intangible nature of the
resulting product, and the uncertain longevity of the files created. While the data may in fact be
three-dimensional, it is not the real thing and should not be viewed as a reasonable facsimile.
While emphasizing the notion that technology can save us all from the unfortunate fate of decay
the statement tends to ignore the more fundamental ideas of original fabric, which is of
fundamental importance to all preservationists. CyArk’s mission is “to ensure heritage sites are
available to future generations, while making them uniquely accessible today” emphasizes the
importance of “ensuring sites” for “future generations” but clearly lacks the emphasis on
tangible original fabric by which these sites were constructed in the first place and on which
reputable heritage organizations place the utmost respect. This forces users of scan data to
generally work within the confines of expensive proprietary systems. While efforts have been
made to establish vendor neutral file formats such as the E57, very little effort is being made to

31 A prototype project to test the concept of a digital archive of 3D survey information of
endangered world heritage sites. archive.cyark.org/
32 Ross, "Cyark Uses 3d Laser Scanning to ‘Digitally Preserve’ World Landmarks; Includes
Babylon, Sydney Opera House, the Titanic".
33 Feldman Land Surveyors to Feldman Land Surveyors.com, 2014,
34 The E57 file format is a compact, vendor-neutral format for storing point clouds, images, and
metadata produced by 3D imaging systems, such as laser scanners. The file format is specified
by the ASTM, an international standards organization, and it is documented in the ASTM E2807
standard. The E57 format was developed by the Data Interoperability sub-committee of
the ASTM E57 Committee on 3D Imaging Systems. An overview of the design and
promote or popularize these. The quote by the director of CyArk, could easily lead one to believe that we only need to scan this building once and we will have saved this site for eternity, and made it easily available to all. Unfortunately, it assumes that this data will easily migrate into future file formats, either those upgraded from existing formats or those, which have yet to be invented.

In addition, the statement fails to address the obvious issue that buildings will continue to deteriorate. A statement like this unfortunately tends to be viewed as an empirical assessment of the importance and usefulness of lasers scanners as they relate to heritage management; however, this type of statement is more of a biased promotional statements designed to encourage the trusting heritage fields to buy into the need for this technology. Does this mean we should scan sites and buildings more frequently to digitally preserve them, or should we place the money required for scanning into actually physically preserving the sites for future generations?

WHERE DO WE GO FROM HERE?

Needs based recording requires good planning and foresight. Thoughtful and proper decision-making about equipment selection, time for recording and processing of the data, money, fragility, and inaccessibility is essential. Important to keep in mind is that “the misapplication or imbalance in these core functions leads to inappropriate data, unnecessary expense and repetition of effort.” This thesis is not intended to dismiss or devalue laser scanning as a tool in recording, but instead seeks to ensure that sound, responsible decisions

implementation of the E57 format can be found in the paper "The ASTM E57 File Format for 3D Imaging Data Exchange." http://www.libe57.org
play a key role in selecting appropriate methods, either traditional or new technologies, and factors in their associated costs (needs based recording). Laser scanning serves as another tool in the full site recorders tool kit, but should not be seen as a replacement for anything and should most definitely never be identified as the only tool. Proper site recording requires many considerations, such as accuracy, precision, product, timeframe, but most of all “the appropriate choice of recording tools and technologies and associated skills for projects must be a function of the available budget.”

Site recorders must understand the value of already established tools and techniques, which are still relevant even in today’s expanding digital world. “The current CAD standards are derived from the visual cues of a non-digital age and the practice of draftsmanship is as relevant today as it has ever been: drawings need to be legible regardless of their origin.”

Given the rapid development and complex nature behind converting laser scan data, or any digital data for that matter, into understood, usable and useful formats seems to point towards a real necessity for creating a standard within the heritage fields for which data is captured. This seems unlikely to take place though, since many organizations, which have traditionally been focused on a standard for the deliverable and not the system of collection have not considered what type of governing entity would be responsible for the digital standard in the first place. The

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37 Although the term CAD standards can be a bit nebulous, countries and governing bodies associated with the architectural and building trades have been working in recent years to develop “CAD standards” such as the National Cad Standard (NCS) which has been developed and supported by such powerful organizations as the American Institute of Architects (AIA), the Construction Standards Institute (CSI) and the National institute of Building Sciences and has been adopted as the standard by such organizations as the US General Services Administration (GSA).
HABS system has been in place for more than 80 years now with each of its governing entities moving forward as best as possible with the limited resources available. Unfortunately, none of them have the expertise necessary to be able to dictate a standard for three dimension digital data capture and conversion. Technology continues to rapidly evolve, and “the ever increasing capacity to capture spatial data has not been matched by a development of standards in its presentation.”\(^{39}\)

\(^{39}\) Ibid.
CHAPTER 4: SIMPLE AND COMPLEX COLLECTION SYSTEMS

Project scale, budget, and scope vary significantly from site to site, therefore the required data collected for satisfying a project’s requirements is quite diverse. Data is captured using fundamentally two groups of tools that for this thesis will be identified as simple and complex. Simple in this case refers to tools, which fundamentally pre-date the digital age and employ direct forms of measurement. Most of these tools require very little training and money to operate. Included in this category are tape measures, pencil and paper for field notes, and simple cameras. The one exception to the “digital” boundary is a digital tape measure also known as a Disto, which fundamentally work just like a traditional tape measure. These tools were and still are baseline for recording. Complex refers to tools which have changed the way recording has been traditionally collected managed and converted. Instruments such as GPS units, total stations and laser scanners require no transcription of the captured data through the use of note pads but instead retain the collected information within their memories. This information is then “converted” using softwares into forms that can be manipulated inside a digital system. These instruments, in addition, to non-digital tools such as photogrammetry as well as the use of non-digital theodolites employ indirect forms of measuring where direct contact with the object in question is minimized or even non-existent. Each of these categories of tools present different advantages and disadvantages and it is not fair to say that one is superior to the other. Regardless of which form of tool the recorder chooses to select, the recorder must answer two key questions prior to the selection of any data collection method: “What do I need?” and “Why do I need it?”

Non-digital information is gathered from site-recording visits, through physical measurements that are then transferred to field notes, whereas digital data employs machines
such as laser scanners, total stations, digital cameras, and Global Positioning Systems. Critical to the recorder’s responsibilities is recognizing that not all data is created equal, and that not all large quantities of data, equate to better data. Collecting a proper type and amount of data begins well before a site visit. A good recording plan starts by fully understanding the project scope and the intended output for the project. From this a site recorder can develop a proper recording strategy using their expertise to make sound judgments, based on a client’s needs, the tools available to achieve these goals, and the available budget for recording.

All good approaches to recording require a balance of foresight creativity, and a strong understanding of all the strengths and limitations of the different tools available, but most importantly a good approach to recording requires proper skills and training, and lack of any of these can lead to wasted field time and money, as well as produce inaccurate results.

**BENEFITS OF SIMPLE**

Simple tools have many benefits, which make their use common within the field of recording. Their low cost makes them appealing for site recorders, as tape measures, levels, profile combs and calipers typically cost on average between $10 and $25 each. The compact physical size of many of these tools allows site recorders to easily transport them to a site. Additionally, their small size and general ease of use can make measuring small rooms and details relatively easy for a single person to accomplish. Even for a beginner, the required training necessary to properly use a tool, such as a tape measure efficiently and accurately takes little time. In addition to compact size and ease of use, the abundant availability of these simple tools make them a desirable component to any site-recorders’ tool arsenal. Even for complex site recording projects, these traditional tools for measuring can be found quickly in almost any
community. Simple tools can be used by anyone but despite the many mentioned benefits associated with them, there are several drawbacks that must be considered.

LIMITATIONS OF SIMPLE TOOLS

Using these traditional hand tools takes time. For large projects, both in terms of area and of frequency of measurement, time can be a major limitation to instruments such as tape measures due to their terminal range, typically under 100’. In addition, as the length of measurements gets larger, their use can require multiple people for efficient use. Fine details and complexity of form can make these simple tools options difficult to use. Tape measures, here in the United States, are broken into 1/16” measurements, making their use in highly precise situations unreliable. While rulers can be purchased that are broken into increments as small as 32nds, in these cases the limit of the ruler is usually no greater than 24 inches. Finally, and perhaps most importantly, the data collected from these types of tools comes in the form of written notes that then need to be transferred into a drawing. This intermediate process can produce errors on both ends due to misreading the instrument or in writing the data down, as well as in reading and drawing those measurements into a final product.

COMPLEX (INDIRECT) METHODS

In recent years, site-recorders have begun using more of these indirect methods in recording our historic sites and buildings. The rapid technological advancement of these tools and their presumed ease of use has emboldened the fields of historic preservation like many others, to use these methods more often.
Photogrammetry

Photogrammetry, defined as “the practice of obtaining information about physical objects through the process of recording, measuring, and interpreting photographic images,” continues to play a major role in how we record historic buildings. The actual relationship between projective geometry and photogrammetry was first developed by R. Strums and Guido Haick in Germany in 1883 long before the digital age. Proper photogrammetry begins through understanding the desired end-product for the user, which most often in recording is a photogrammetric survey or a line drawing. In order to achieve this, the photogrammetrist will take suitable photographs, often stereoscopic, and establishing a ‘control’ network to determine the scale and orientation of the photographs and to enable accurate photogrammetric analysis." Once the site visits are complete, the majority of the work typically commences back at the office, with the required photographs and measurements captured from the photograph and formatted for use in most computer-aided software such as AutoCAD. The accuracy of photographic survey for recording of buildings is directly linked to two items, ease of access to the object being photographed and the required scale of the photographs taken. Photogrammetry, while appearing simple in concept, is a complex approach to capturing measurement and to do it accurately requires extensive training and skills. Professional photogrametrists do exist and have standards by which they perform their duties.

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41 A control network refers to measurements taken using “taped distances on the façade of the building or the establishment of three dimensional coordinates of either target markers or identifiable points of detail.” (ibid.)
42 Ibid.
43 Ibid.
44 Ibid.
Theodolite Survey

A total station, or electronic theodolite, is an electronic/optical instrument used in modern surveying and building construction. Integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point, these instruments are primarily associated with surveying, although total stations are often used in the recording of historic sites and buildings. Key for gaining accurate data, are the skills and training necessary to properly level, center, and operate the unit. Improper execution of any one of these steps may lead to inaccuracies in the measurements. Looking through the telescope on the total station, the operator “aims the cross-hairs of the telescope at the target and the slope distance, angle of rotation (horizontal angle) and angle of inclination (vertical angle) are recorded based on the current establish location of the instrument.”45 Each captured location in space is given a point code, which is recorded digitally in one of two ways, either within the total station’s memory, or using a data logger connected to the instrument.46

Global Positioning Systems

A Global Positioning System, or GPS, is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.47

46 Ibid.
every twelve hours at an altitude of 20,200 km\(^{48}\) each transmitting time and navigational
information on two radio bands. Recording devices using GPS receivers (and there are many,
both high and low quality)\(^{49}\) follow the same basic steps for obtaining data. Once the receiver is
turned on, it “starts searching for signals from the GPS satellites, referred to as acquiring
satellites or satellite lock.”\(^{50}\) Once the receiver obtains these signals from a minimum of four or
more satellites, often taking between “15 minutes and an hour,” for the initial location, data
recording begins.\(^{51}\) The receiver then processes these “satellite signals and creates raw GPS
coordinates expressed as two angles and a distance in relation to the earth’s gravitational
center, converting them into latitude, longitude, and elevation or one of the many conventional
Cartesian coordinate systems.”\(^{52}\) Key to understanding collecting GPS data is that not all GPS
receivers are created equal. There are three grades of GPS equipment consisting of navigations-
grade, mapping-grade, and survey-grade\(^{53}\), and having the proper skills and training to

\(^{48}\) “Where on Earth Are We? The Global Positioning System (Gps) in Archaeological Field Survey,”
\(^{49}\) Google recently launched a project where cell phone users can use their cell phones to laser
scan objects. (http://www.laserscanning-europe.com/en/blog/google-tango-project-scan-the-
\(^{50}\) William R. Fitts, “Precision Gps Surveying at Medieval Cottam, East Yorkshire England,” Journal
of Field Archaeology 30, no. 2 (2005): 182.
\(^{51}\) Ibid.
\(^{52}\) “Precision Gps Surveying at Medieval Cottam, East Yorkshire England,” 184.
\(^{53}\) “Where on Earth Are We? The Global Positioning System (Gps) in Archaeological Field Survey,”
9.

The three categories of GPS units:
**Navigation-grade GPS** units have a map accuracy and absolute accuracy approximately at 10m.
Units that fall into this category are “good for finding location in relation to maps and relocating
sites, but are not survey quality. If height information is required, this unit is very unreliable.
**Mapping-grade GPS** units have a map accuracy and absolute accuracy down to 1m, either onsite
at the time of recording or later in post-processing. Units in this category are suitable to a
1:2500 scale but still not survey quality.
**Survey-grade GPS** has centimeter relative accuracy. Units falling into this category have a map
accuracy and absolute accuracy to the nearest 100mm, and this accuracy can be achieved onsite
or through post-processing.
understand the capabilities and limitations of these units prior to selection must be undertaken in order to satisfy the GPS requirements set forth in a project’s scope. In all three cases skill and training are required to use a GPS properly, and yet many people who use them for recording are not properly trained, not even knowing the fundamental difference between the three different grades.

Three-Dimensional (3D) Laser Scanners

The definition of a laser scanner (FIGURE 2) is “any device that collects 3D co-ordinates of a given region of an object’s surface automatically and in a systematic pattern at a high rate achieving the results in real time.”\(^5^4\) This means that as the scanner collects data, a coordinate based file is being created that can then be used to create a point cloud.\(^5^5\) There are several different types of scanners, which utilize different technologies. (For more information on the 3 basic types of laser scanners, SEE FIGURE 3 AND APPENDIX A).

BENEFITS OF COMPLEX TOOLS

Complex tools for recording such as three-dimensional (3D) laser scanners and total stations can have benefits for the site-recorder. For large-scale sites and sites with limited accessibility, these digital tools allow the site-recorder to obtain measurements, which would otherwise be difficult using simple direct measure tools. Many total stations have the capability of capturing data using reflectorless\(^5^6\) measurement, where the user measures points without


\(^{55}\) A point cloud is a set of data points in some coordinate system. While a the term “point cloud is most commonly associated with a laser scanner, point clouds are really any set of points represented in three dimensions so data from total stations and GPS units actually fall under this category as well.

\(^{56}\) Heritage, "Traversing the Past: The Total Station Theodolite in Archaeological Landscape Survey," 6. Reflectorless total stations do not require a retro-reflective prism as the target to achieve a measure.
the use of a prism to reflect the laser back to the instrument. This can increase the speed by which the user captures points and allows measurement of points where placing a prism is not an option\textsuperscript{57}. While complex tools capture large amounts of data quickly when compared to more labor-intensive simple tools, the time spent working with the data can still be intensive.

LIMITATIONS OF COMPLEX TOOLS

Complex tools have many drawbacks and limitations beyond the obvious need for extensive training that the site-recorder must consider prior to selecting them. Understanding the working range of the instrument is critical, as in the case of some total stations, which “have a minimum range of 2-5m which may be too large for some recording projects. The cost associated with this type of equipment can generally be higher than simple tools. Laser scanners can cost upwards of $100,000, total stations upwards of $10,000, GPS units can start at $200 for low end units and go as high as $8,000 or more for higher grade equipment. The added costs associated with computer hardware and software to handle the resulting data is often overlooked or ignored, and the training required to properly operate the equipment can run $150 an hour\textsuperscript{58} (SEE APPENDIX B). In addition, post-processing the data into a usable format is a major undertaking, which can easily remove the presumed benefit of time savings over a more traditional system\textsuperscript{59}. Rain, fog, and airborne particles\textsuperscript{60} and even heat can affect the performance of these instruments, which utilize laser light and require a line of sight, between the user and the object being measured. “GPS surveying requires an unobstructed view of a large portion of sky. Overhead obstacles like roofs, tall buildings, or dense vegetation can block

\textsuperscript{57} Ibid.
\textsuperscript{58} Cost from phone conversations with New Mexico based laser scanning company
\textsuperscript{59} Ibid.
\textsuperscript{60} Heritage, “Traversing the Past: The Total Station Theodolite in Archaeological Landscape Survey,” 5.
the satellite signals, sometimes to the point where surveying with GPS receivers is impossible.\textsuperscript{61} Despite these limitations, many assume that “GPS receivers can be used in all weather, day or night anywhere in the world.”\textsuperscript{62} Total stations have unique problems associated with range, and reflectance, which can impact the data captured. The obliqueness of the object, meaning that variations in the surface of the object being measured can lead to inaccuracies, as the signal does not have a defined point to reflect from may impact collected data. Darker surfaces offer very poor reflectance, and these surfaces may not allow the laser to return to the device\textsuperscript{63}. To avoid these unique problems requires proper training, and additional problems such as portability, loss of power, and fragility for any of these devices must not be overlooked.

While many complex indirect tools exist, and not all of them are digital, one of the most talked about complex tools is the laser scanner. While laser scanners have become quite popular due to their apparent ease of use and quick capture, the process associated with converting laser scanner data into a usable product can be difficult and time consuming (SEE APPENDIX C).

SOFTWARE

Software clearly plays a pivotal role in the conversion from raw point data to a final two-dimensional drawing. In the initial stage a scanners has its own self-contained software known as firmware that is used to collect the data. The next stage may require additional software such as FaroScene, to pull the data from the device and convert it into a point cloud on a computer. Next, there might be several softwares such as GeoMagic, RapidForm or Rhino, needed to

\textsuperscript{61} Fitts, "Precision Gps Surveying at Medieval Cottam, East Yorkshire England," 183.
\textsuperscript{62} “Where on Earth Are We? The Global Positioning System (Gps) in Archaeological Field Survey," 3.
\textsuperscript{63} Heritage, “Traversing the Past: The Total Station Theodolite in Archaeological Landscape Survey,” 6.
convert the data from points, to mesh, to NURBS drawings and finally 2D CAD. These software programs are usually proprietary and often expensive\textsuperscript{64}, and require properly trained individuals to operate and extract the data. Having a well-trained person on staff can be expensive and that type of position is usually not the type of position readily available in heritage management, placing the user at the mercy of the laser scanning company to convert the data for them, and usually at great cost.

**HARDWARE REQUIREMENTS FOR SOFTWARE OPERATION**

As discussed earlier, 3D laser scanners produce millions and sometimes billions of points to create their point cloud, resulting in an incredibly large data file. As the file size gets larger, higher demands are placed on a computer’s processor to operate. The larger files require a faster processor and more RAM to handle this increased data, and desktop computers with lower specifications may not be sufficient, requiring increased user investment in expensive computer hardware to access their data.

Preservation must navigate between simple and complex tools for data collection, and often times use a combination of the two. This combination of tools can enhance the recorded data by using the benefits of the most appropriate tools for specific situations, however, this also poses a problem in that the field of Preservation is usually short on funds, and unable to afford the more expensive tools.

Regardless of whether the data collected comes in the form of analog or digital, the site recorder must understand the benefits and limitations of many tools in order to make well-informed choices in the recording process. Unfortunately, the field of Historic Preservation does not contain a benchmark for those claiming to have expertise in many of these tools.

\textsuperscript{64} Based on conversations with New Mexico based scanning company, these software’s cost upwards of $10,000
Certification plays a pivotal role in establishing professional standards in many fields, such as architecture, engineering, and surveying. Through this certification process, these other professions provide an excellent example, which Historic Preservation could to establish their own standards for recording our historic sites and buildings.
Unlike industries such as surveying, site recorders do not have set standards for how to record our historic sites, leading to wide range of data in terms of format and quality. There should be more checks and balances within the field to hold recorders accountable for their decisions on data collection, acting in the best interests of the user and the future users of their data. Many organizations, such as HABS, have given recorders the best option on how to produce final product, however there is no set methodology for how and when to use expensive complex systems such as a laser scanner, total stations and GPS units. Creating standards or set methodologies in the preservation fields however will not provide a 100% guarantee that the recording data is perfect for the user and the current level of standard leaves the user at the mercy of the provider who claims expertise.

Preservationists can learn a lot about the importance of training and skills and professionalism when considering the certification requirements and processes that architects, engineers, and surveyors follow in order to establish competency in their respective fields. These professions represent just a few of the many disciplines that require a formal path for those wishing to claim expertise in their field. With these certifications come a great deal of education, financial commitment, and skills in order to join the ranks of those certified as experts. Historic Preservation does not have a formal set of standards or guidelines to be considered a preservationist although there are “governing” bodies and treatises, which serve that purpose to a certain extent. Consider the Secretary of Interior Standards, which were
written not as rules, but “intended to promote responsible preservation practices that help protect our Nation's irreplaceable cultural resources.”\textsuperscript{65} Often referred to as “The Standards,” these guidelines are meant to provide professional guidance on both the proper methods and necessary qualifications covering our historic buildings and sites in the United States. The Department of the Interior oversees the implementation of these standards by The National Park Service, and many topics related to the proper skills and training required to preserve our historic sites is included. Topics covered include Standards for Preservation, Standards for Rehabilitation, Standards for Restoration, and Standards for Reconstruction of historical buildings and cultural resources and Standards for Qualification.

Consider what HABS is designed to do for the fields of preservation and it becomes evident that there are entities, which are intended to set “standards” for work within the field. Although these entities do exist, there is no certification exam one has to pass, nor are there continuing educational requirements to illustrate competency as there are in other “registered” fields. In hiring an architect, engineer, or surveyor, most questions of responsibility and deliverables are already answered. Proper training has presumably provided the necessary skills, and the licensing exams, have confirmed that the individual in question has those skills. Unfortunately, this lack of standardization in the fields of preservation opens up more questions than answers. If there is really no formal certification in the field of preservation, what is to keep anyone from stating they are qualified to record a building or site? And once the site is recorded, do the site-recorders and users have the knowledge to distinguish between good data and bad data?

WHAT IS A PROFESSIONAL?

The term professional[^66] is often loosely used in the combined fields of Historic Preservation, however actual professional certification sets the bar very high, and with that comes a level of competency as far as skill is concerned, as well as the a presumed “moral” judgment to make good well informed decisions and provide reliable good quality product for the client. In fact, it is very unusual for a professional certification entity not to somehow address the issues of moral standard. The State of New York licensing board lists the first requirement for a licensed surveyor in the state of New York to “be of good moral character” and section 1 subsection A of the land survey guide, the “Practice of a profession” states that the practice of a profession in a public trust, earned through education preparation experience, and examination and a commitment on the part of the practitioner to public service.” This same section goes on to say that “professional practitioners are urged to be always conscious of the special obligations of public service and of ethical conduct that the privilege of licensure creates.”[^67] Clearly moral judgment is considered with the utmost of importance based on the “public” or “user” trust.

Certification is important for the professional within a given field, but there is nothing in place that distinguishes someone coming off the street and claiming to be a preservationist from those that have formalized training in the field. This puts site recording of historic sites and buildings and those unlicensed that undertake recording techniques in an unfavorable position. For years, professions such as architects, engineers, and surveyors have applied educational requirements and certifications by law as a prerequisite for those claiming to be a professional

[^66]: For the purposes of this thesis, a professional is defined as relating to a job that requires special education, training, and certifications in order to claim expertise.

in their respective fields. Along with this education, and training, these professions have also placed additional requirements after the initial education and certification in order to maintain this status throughout their career. For the purposes of this discussion, fields closely associated with preservation have been explored: including architects, engineers, and surveyors, but paying particular attention to architects.

REGISTRATION

The path to becoming a registered architect has evolved greatly from its origins. Originally, architects were tradespeople such as stonemasons and carpenters, and did not require much formalized training or certification. They were known as master-builders, in charge of both design and involved in the actual construction of the building. Today, an architect is “a designation reserved, usually by law, for a person or organization professionally qualified and duly licensed to perform architectural services, including analysis of project requirements, creation and development of the project design, preparation of drawings, specifications, and bidding requirements, and general administration of the construction contract.”

We can see that the architect has many responsibilities to oversee, and this requires a vast amount of educational and professional training.

EDUCATION AND TRAINING

Requirements for obtaining licensure follow a strict format, as one needs a professional degree from an accredited university or college. After obtaining an accredited degree many falsely believe they are then architects. Although they have an accredited degree in Architecture, they cannot claim to be an architect, but instead can only claim that they have satisfied the educational component and received architectural training. The licensing and

completion of certification tests are actually not even part of architecture school, but are tests administered by the National Council of Architectural Registration Boards (NCARB)\(^69\) and the testing is quite extensive.\(^70\)

Architects are in charge of projects that affect public health and safety, so while registered architects carry the liability associated with these issues, much of what certification provides is a stamp of approval by the governing bodies in architecture that indicate that a person has met both the required skills as well as the “moral” standards that are expected by these organizations. Key to the successful understanding of these important factors, graduates in architecture must learn from those that have the experience to guide them into professional practice of architecture through working directly under a licensed architect or established professional, which is known as the Intern Development Program (IDP)\(^71\). This type of educational experience is also used in preservation, particularly involving the internship process, but the practice of it could be more widespread and extensive. Recording does not have the same level of safety issues associated with the work, that architecture does in its own right demonstrate issues related to the quality of the recording, not to mention the issues of good judgment.

\(^{69}\) The Architect Registration Examination\(^*\) (ARE\(^*\)) assesses candidates for their knowledge, skills, and ability to provide the various services required in the practice of architecture. The ARE has been adopted for use by all 54 U.S. Member Boards and the Canadian provincial and territorial architectural associations as a registration examination required for architectural registration. [http://www.ncarb.org/are.aspx](http://www.ncarb.org/are.aspx)


\(^{71}\) For more information on the Intern Development Program please look to the Figure:8
CERTIFICATION CONTINUING EDUCATION RECIPROCITY

Once an intern completes all the necessary IDP hours and successfully passes all seven of the ARE exams, they are allowed to apply for licensure. In recent years, the requirements for licensure have become more standardized across the nation; however each state still is in charge of their own licensing requirements. Once licensure is received, requirements for continuing education must be met, either annually or bi-annually, and there are associated fees that are required to maintain this licensure. Gaining licensure to practice architecture in one state does not mean one is licensed in all states. Again, each state has its own rules, but generally, a licensed architect in one state can obtain licensure in another through reciprocity of exams and paying administrative fees.

Unfortunately, there is the misconception architects only produce drawings. Their responsibilities go much further, as architects are in charge of many facets of the process including design and project management. They take on a great deal of risk, as they are in charge of the health and safety of the public, with code requirements and laws as one of the critical components that all architects must abide by. Adherence to codes is a requirement of being an architect, dictating what they can and cannot do within their designs, as a way to protect the public. Preservation is more than just history and the responsibility of preservationists are wide ranging, but in general preservation does not have this type of licensing and therefore does not have the oversight for ensuring proper recording procedures and techniques, occasionally leaving the users or clients at the mercy of what each recorder feels is the most appropriate method of capture as well as deliverable. The Preservation field could take steps to ensure that those conducting site-recording are properly educated, trained,
and certified before undertaking a project helping to ensure, as with the licensing of an architect, that the client will receive a good product in a usable and useful format.

ENGINEERS

Becoming a licensed engineer is a similar process to architects. Formal education, professional experience, and examinations are all part of the process, as well as good moral character. An engineer is “a person trained and experienced in the profession of engineering: a person licensed to practice the profession by the authority in the area.” Engineers are in charge of many areas that directly impact the public, such as bridges and buildings, and proper training is essential to protect the public. The NCEES (National Council of Examiners for Engineering and Surveying) “is a national nonprofit organization dedicated to advancing professional licensure for engineers and surveyors.” According to their website, in regards to becoming a professional engineer, they believe that “professional licensure protects the public by enforcing standards that restrict practice to qualified individuals who have met specific qualifications in education, work experience, and exams.” This combination of education,

72 Article 145 subsection 7206.6 of the New York Professional Engineers states that in order to be a licensed engineer “Character: be of good moral character as determined by the department” (http://www.op.nysed.gov/prof/pels/article145.htm) Accessed on May 5, 2014.
76 The first step in the process of becoming a licensed engineer is to obtain the proper education. This is done through the successful completion of an ABET accredited degree program.

“ABET is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology”( http://www.abet.org/about‐abet/) These accredited programs prepare graduates through intensive courses focusing on math, and physics, culminating in passing several exams.
work experience and exams\textsuperscript{77} is another attempt to safeguard the public.

\textbf{PROFESSIONAL EXPERIENCE}

As with most professions, there is only so much one learns from the classroom environment or through exams. Professional experience is an essential component for professionals in their chosen field. For Engineers, obtaining experience under the direct supervision of a licensed Engineer takes approximately 4 years.

Engineers go through a rigorous education and professional training, as should be expected for a field that so directly impacts public safety. Professional certification comes with a lot of responsibility, which Engineers do not take lightly. Designs stamped and signed by an Engineer are legal documents, and therefore come with a great deal of liability.

\textbf{SURVEYORS}

While architects and engineers are related to the fields of preservation through their direct link to the built fabric, neither of those fields are fundamentally focused on the process of recording (although recording is a necessary component). Clearly licensing makes sense for both, since safety is so much of a concern. Recording as it is identified in the fields of preservation does however have a more closely connected field, where similar tools and ideas are employed and which does require licensing. Licensed surveyors must go through multiple

\textsuperscript{77} There are two primary exams that aspiring engineers must take. The first exam is the Fundamentals of Engineering or FE exam, and is for recent graduates. This 6-hour, 110-multiple-choice exam costs $225, tests student knowledge of the fundamentals of engineering. \texttt{http://ncees.org/exams/fe-exam/}. The second exam is known as the Principles of Engineering, or PE exam, which tests your ability to practice competently in a particular engineering discipline. Designed for engineers who have gained at least four years’ post-college work experience in their chosen engineering discipline. Each PE exam lasts 8 hours and costs $225, \texttt{(http://ncees.org/exams/pe-exam/)}. 

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steps, including education, examinations and professional development before they can practice professionally. This draws several parallels to both architects and engineers, but the surveyor does not face the same safety issues related to those professions. The surveyor’s responsibility lies in ensuring that the surveyed land obeys the boundaries of property ownership. Given the transfer of land ownership, a great deal of care must be taken by the surveyor to make sure the survey is correct. Imagine if an owner built their house on a plot of land that they had professionally surveyed, only to find out they built on someone else’s land! Each state is in charge of their requirements, so it is important to look specifically at each state to understand what is required for becoming a licensed surveyor in that state. Similar to both architecture and engineering, for surveying there are four steps to obtaining licensure: education, either high school diploma or a four-year surveying degree; passing the Fundamentals of Surveying exam, aka FS Exam; generally four years of professional work experience working under the direct supervision of a licensed surveyor or qualified professional; and finally passing the PS exam. While the specifics are slightly different, it is clear that focused education, training, and professional mentorship are necessary.

EDUCATION

There are only a few accredited programs in the United States for a degree in surveying, however proper education is a key component for licensing. The program at Penn State is one example of an accredited program in surveying, and exposes their students to the techniques and responsibilities that surveyors require. The program emphasizes the importance of understanding the basic principles of surveying, which include “land surveying, mapping, photogrammetry, data analysis and adjustment, geodesy and map projection coordinate
systems, remote sensing, geographic information systems, and land development.” The program also exposes their students to various tools and techniques that the field of surveying utilizes. These tools include “total stations, levels, softcopy photogrammetry, satellite imagery, and the global navigation satellite system (GNSS),” as well as studying the “legal principles related to land surveying, professional ethics, applications for Geographic Information Systems (GIS) in surveying, and data management techniques.” As discussed in previous professional certification requirements, education only goes so far, and surveyors are required to pass multiple exams.

EXAMINATIONS

The examination process for surveyors most closely resembles that of the engineering requirements. The Fundamentals of Surveying (FS) exam is typically the first step in the process leading to the P.S. license. This exam, designed for recent graduates and students whom are close to completion of an undergraduate degree, lasts six hours, is comprised of 110 multiple choice questions, and costs $225. The goal of this exam is to show competency in the fundamentals of the surveying field.

LICENSURE AND MAINTAINING LICENSURE

Not anyone can claim to be a surveyor, as every state in the United States “requires those who perform the tasks defined as the practice of surveying to hold a professional

79 See APPENDIX C fpr Penn State- Wilkes Barre recommended academic courses for the B.S. in Survey Engineering Degree.
surveying license."\textsuperscript{82} Most jurisdictions also require those surveyors licensed to continually keep up with the latest standards of the profession. Completed through what is known as Professional Development Hours, or PDH, these continuing education requirements ensure surveyors constantly stay educated in current survey methods and techniques. From the outside, it may seem like there are fewer requirements placed on surveyors, but the point here is that there is a guide to showing competency. Having the proper educational training, professional training, and passing required exams is all part of the process to ensure high-quality standards within field, and protecting the public from negligent recording.

Certification plays a central role in adding professional legitimacy to the fields of architecture, engineering and surveying, and although this may not be realistically feasible to implement in the field of Historic Preservation, especially for the sub-field of recording, these other professions should serve as a guide and clearly show the benefits and assurances that come for both the professional and their clients. Certification serves as a mechanism for illustrating competency, such as the requirement to hold a valid driver’s license to legally drive a car. Although this does not guarantee perfection in driving, it gives other drivers some assurance that those driving around them have the ability to operate their vehicle safely and to an accepted standard. Historic Preservation covers a wide range of projects, both big and small, and proper educational standards and experience should serve as a baseline in which people in the field can call themselves a recorder. This not only could add credibility and legitimacy to the profession of recording, but would also serve to protect those that seek the services of a preservationist and ensure them that they will receive a quality product from a competent and well established professional with good judgment within the field.

\textsuperscript{82} Ibid., 2014.
CHAPTER 6: JUSTIFYING COSTS?

All sites are different and there are many factors, which need to be considered when deciding what tools to use for recording. Decisions about what and how to record have always been a significant challenge to preservationists and dwindling project budgets, often small to begin with, seem to counter a current trend towards more complex expensive recording systems. Proper site recording tools and methods, regardless of what them may be, must be considered in any professional site recorder’s decision process. And, as with the professional fields mentioned above, there obviously must be a moral imperative when making a decision where cost must be a motivating factor. The goal for this thesis has been to act as the third party between the user and provider when looking at recording; not favoring one technique over another, but exposing the lack of knowledge and standards within site recording in the implementation of modern complex recording systems. To outline the complex cost structures associated with these systems lets look more closely at one system in particular. There is a time and place where laser scanning is the best option, however the idea that laser scanning is always the best or most efficient technique has many flaws when considering the deliverables required of each project, as well as the available budget and timeframe.

The cost of laser scanners and the training to use them is expensive. The providers who use this technology are clearly aware of all these associated costs; however a current trend is often for the provider to disguise the true cost of on-site laser scanning. For this thesis, an attempt was made to gather comprehensive data on the associated costs for such things as equipment, operation, training, as well as a timeframe for conversion of laser scan data into
‘useful’\textsuperscript{83} formats in an effort to compare the presumed benefits with the actual costs, to determine if the use of these newer more complex systems was justified. Unfortunately, the results of the survey were limited due to little commitment on the part of those polled. What motivated this limited response is unclear but from the small amount of data gathered, it is clear that there may be no standard approach for identifying costs for these more complex systems of recording. Research for this thesis showed that many scanning companies and organizations were willing and eager to promote the benefits of laser scanning, however when it came to discussing the limitations and costs of the process they were generally less enthusiastic to share. Following an extensive search, the resulting values were created using data obtained from only a single laser scanning expert. Hard numbers from different sources were difficult to obtain for many reasons, including the lack of an actual project requiring scanning services (values could not be provided without knowing what was being scanned), the confidentiality of exposing project budgets, as well as concern for how the cost data may be used (full transparency is a clear indication of having no secrets to hide). The resulting assessment of the data here in this thesis is meant to fill in many of the gaps for potential users of laser scanning, however a more comprehensive “cost benefit analysis” in the future could provide more refined results. In discussions with providers, it was stated upfront that research would focus on the costs versus benefits of laser scanning, and that the intention was not in any way meant to promote or discredit the use of laser scanners in recording. Instead, it was intended to help understand the process, deliverables, and costs associated with this technology. Despite full disclosure of the thesis goals, many of the employees of organizations interviewed seemed nervous about what

\textsuperscript{83}“Useful” refers to data that can be used immediately for more than just visual graphics such as walkthroughs and visual graphics
the intentions for dissemination were when asked about the costs associated with the post-processing of laser scan data into deliverables such as two-dimensional CAD type drawings.

The cost for a laser scanner alone can be over $100,000\textsuperscript{84}, and while the prices of scanners have slowly declined over the years as the technology becomes more widespread, it is likely that we will not see the price of survey grade\textsuperscript{85} scanners falling to levels comparable to other complex recording systems, such as total stations. It goes without saying that these costs will never diminish to the level of more traditional tools such as tape measures. If high precision and accuracy are touted as key benefits to scanning with the current high cost of the equipment, how can one justify using this technology when “normal drafting tolerances are specified”? Statements such as this serve as a reminder of the importance of understanding what is to be recorded and why. The tolerances of a given project should be one of the first things to aid in the decision process when choosing the method of documentation to be employed. When systems that employ simple tools at reasonable costs can produce the required results, a recorder has an obligation as a professional to choose these tools over the more expensive complex systems.

The outcome of another discussion with an organization that utilizes scanning helps support the necessity for a third-party role in justifying the use of laser scanning technology in preservation projects. In an email the respondent stated: “Our budgets don’t really reflect the cost of the laser scanner, high-end computers and all the special software needed to migrate the

\textsuperscript{84} Kakrzewski, "Uf Program Gets Laser Scanner to Preserve History".

\textsuperscript{85} Other products are in research that may offer cheaper alternatives, such as Google GPS for your phone but you get what you pay for. These newer techniques do not offer the quality or resolution that larger professional “survey grade” systems do.
Clearly there are costs associated with hardware, software and training and to say that the costs of a project do not actually reflect them seems to be attempting to justify costs without actually having to justify costs. There has to be some justification and accountability for use of such high cost technology. This lack of justification seems to ignore the notion of “needs based” recording where all factors, including costs (SEE APPENDIX A)\textsuperscript{87}, must be included in the decision making process.

Recording our historic sites requires recorders to consistently evaluate and understand what are the most appropriate and cost effective techniques. Through training and experience, a provider must understand a project scope, and budget for guiding the owner through the recording project. Being transparent and open about the available techniques, all of the costs associated with them, as well as the benefits and limitations is critical. The creation of standards by which the user will hold the provider to, and the provider can abide by, is key for making sure that all parties understand their roles and responsibilities. If a user is not trained properly, they will not know to ask the tough questions regarding actual costs necessary to take data from a laser scanner and turn it into something useful. Even with all of the software and hardware, at the end of the day the resource team needs employ a person who can manipulate the data for future projects, and who understands the limitations of the available data. Unfortunately, these people are rare, helping to emphasize the need for training and standardization.

\textsuperscript{86} This statement can be read in more than one way. Clearly it shows that costs for this type of capital purchase are generally amortized over time and therefore don’t get included as a line price in each project, however all equipment, costs, personnel and training must be factored in somewhere.

\textsuperscript{87} Appendix A outlines the costs associated with owner operating and maintaining a laser scanner. Due to the limited number of respondents to my requests for pricing, my outline of costs is unfortunately based on only one individual who was willing enough to be fully transparent.
CHAPTER 7: CONCLUSION

Site-recording is an important component for almost every project associated with the built fabric in the preservation fields, however there is not a perfect template to ensure its success. A provider, in this case the site-recorder, requires a vast amount of skills, including technical, verbal and written, and there is no certainty that their background will provide them to a requisite level. Through a strong understanding of all the available techniques used for recording, along with the benefit and limitations of each individual technique a site-recorder can make good decisions about what they should and should not be using in any given situation. The status of “professional” requires this type of deep knowledge of techniques, as well as sound judgment based on experience and a well-defined understanding of the needs of any project. Understanding the costs associated with each technique is just as important as understanding the techniques themselves and it is through good judgment of an individual that decisions are made to ensure that the best tool is used for a project. Every technology, from tape measures to laser scanners, has a place in the recording of our historic sites; however, the historic preservation field faces the problem of a lack of proper knowledge associated with skills and training as to which situations justify the use of available techniques. This lack of knowledge may be due to the different educational experiences to which a recorder has been exposed. Inconsistent training for these professionals has the potential to lead to misguided, wasteful spending of budgets, and improper use of technology for recording our sites. The lack of certification standards in the field of historic preservation allows recorders to make questionable decisions that may not be the best for a project both in terms of final product and in terms of costs associated with the chosen process.
While no two preservation projects are the same, a properly trained site-recorder with experiences on multiple types of sites, and working with an established professional, will be better suited to making informed decisions. This is not to say that preservation should completely copy other professions such as architecture, engineering and surveying in order to establish a certification program. It is important though for Preservation to look to these professions, and see how these professions have defined a standard for professional practice. A stronger base of skills, possibly defined by some form of certification, would allow both the provider and user to create a baseline of what training and experience recorders bring to the project.

Costs, regardless of whether anyone wants to admit it, should always play a significant role in the decision-making process of recording. As more tools, especially those that are digital, become available for recording, understanding the costs associated with the purchase, operation, and processing of the data must be better understood and appreciated especially in regard to a given project’s overall budget. Unfortunately, this research was unable to create a complete cost-benefit analysis comparing multiple companies, because both providers and users were hesitant to share these costs. This is a troubling revelation that must be explored in the future, because recording is expensive, especially when it comes to complex modern systems that depend on expensive equipment, software and training. If the costs of these tools are not readily accessible for analysis, then either the site-recorder or the user (or sometimes both) are left in the dark as to what a recording project may cost.

Site-recording of historic sites and buildings relies on using multiple tools to execute proper recording, and proper educational training and professional development is paramount to the success of each project. Site-recorders must avoid the belief that one magic “black box”
tool satisfies all of the recording needs, despite the claims made by those promoting digital technologies. But along with proper “professional” training comes the ethical responsibility of recorders to do the right thing and not always turn to the latest magic solution.

While the provider is fundamentally responsible to make the right decisions about when and where to use a given tool, the responsibility does not lie entirely in their laps. A well-informed customer has a greater capacity to understand the importance of their actions and choices, and are enabled in making better choices about what they need and how they need it. So whose job is it to train both parties and how should that training be executed? Clearly much of the information coming from the companies who provide services are more akin to promotions material, where the consumer hears just what the providers wants them to. In return, a provider can legitimately have troubles interpreting what a user wants without clearly defined product expectations. Specification sheets are typical of the architectural industry and perhaps those types of sheets need to be more commonplace. While they do exist, they unfortunately can often be copy and paste “boilerplate” descriptions written by an uninformed client. Clearly there is no easy answer, but even without solutions all of the above issues need to be wrestled with to find the right path.

As discussed earlier, architects, engineers, and surveyors, implemented these standards for their fields’ decades before as a means for establishing education standards, professional development standards, standards for passing exams, all with the goal of establishing legitimacy for quality professional work for each of these fields. The responsibility lies within the field of historic preservation to develop and enforce professional and certification standards for site-recorders as a means of establishing credibility and legitimacy to the field, as well as ensuring
quality and protection for clients seeking professional quality documentation of historic sites and buildings.
BIBLIOGRAPHY


FIGURES:

Figure 1: Leica Viva TS11 Total Station
http://www.allenprecision.com/leica-viva-ts11-total-station/
Figure 2: Faro Focus 3D X330 Laser Scanner
http://www.surveyequipment.com/laser-scanning/faro-focus-3d-x330-laser-scanner#.u1s7ZF5sfdg
Figure 3: LiDAR schematic
http://forys.cfr.washington.edu/JFSPO6/lidar_technology.htm
Figure 4: Point Cloud
http://www.totalsurveys.co.uk/services-provided/laser-scanning-surveys.aspx

Figure 5: Polygon Mesh
Figure 6: Triangulated Mesh
Figure 7: NURBS drawings
http://www.web3d.org/files/specifications/19775-1/V3.3/Part01/components/nurbs.html
IDP 2.0: 5,600 HOURS
All interns must earn 3,600 total hours to complete IDP.

Core Experience Hours: 3,740
Experience earned in IDP 2.0 categories and areas. Core minimum hours are the minimum number of hours you must earn in a given experience category or area. Experience can be earned in any combination of experience setting A, experience setting C, and opportunities that qualify for core hours in Experience Setting 5 (see page 19 for a detailed list).

<table>
<thead>
<tr>
<th>Area</th>
<th>Hours</th>
<th>Core Minimum Hours</th>
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</thead>
<tbody>
<tr>
<td>1. Pre-Design</td>
<td></td>
<td></td>
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<tr>
<td>A. Programming</td>
<td>80</td>
<td></td>
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<tr>
<td>B. Site and Building Analysis</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>C. Project Cost and Feasibility</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>D. Planning and Zoning Regulations</td>
<td>60</td>
<td></td>
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<tr>
<td>2. Design</td>
<td></td>
<td></td>
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<tr>
<td>A. Schematic Design</td>
<td>110</td>
<td></td>
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<tr>
<td>B. Engineering Systems</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td>C. Construction Cost</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>D. Codes and Regulations</td>
<td>110</td>
<td></td>
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<tr>
<td>E. Design Development</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>F. Construction Documents</td>
<td>1,350</td>
<td></td>
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<tr>
<td>G. Material Selection and Specification</td>
<td>180</td>
<td></td>
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<tr>
<td>3. Project Management</td>
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<td></td>
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<tr>
<td>A. Billing and Contract Negotiation</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>B. Construction Administration</td>
<td>240</td>
<td></td>
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<tr>
<td>C. Construction Project observation</td>
<td>110</td>
<td></td>
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<tr>
<td>D. General Project Management</td>
<td>240</td>
<td></td>
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<tr>
<td>4. Practice Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Business Operations</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>B. Leadership and Service</td>
<td>80</td>
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</tr>
</tbody>
</table>

Elective Experience Hours: 1,860
You can earn elective hours in any experience area, or through certain supplementary experience opportunities for elective hours (see page 19 for a detailed list). Any hours earned in an experience area in excess of the core minimum hours required will count as elective.

<table>
<thead>
<tr>
<th>Area</th>
<th>Hours</th>
<th>Core Minimum Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Hours in 1. Pre-Design</td>
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<tr>
<td>Additional Hours in 2. Design</td>
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<tr>
<td>Additional Hours in 3. Project Management</td>
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<tr>
<td>Additional Hours in 4. Practice Management</td>
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</tr>
</tbody>
</table>

All interns will be required to meet the 3,740 core minimum hours in IDP 2.0.

3,740 + 1,860 = 5,600

TOTAL HOURS

Figure 8: Intern Development Hours
APPENDIX A: LASER SCANNING DESCRIPTIONS

TERRESTRIAL SCANNERS

Terrestrial Laser scanners work by calculating the time it takes for a laser pulse to pass from the scanning device to the scanned item, and back to the scanning device. Scanners in this category have lower resolutions and therefore should only be used for capturing basic features of a scanned object such as general building facades, and not for replicating high detail work.  

PHASE-COMPANION SCANNERS

Similar to Terrestrial Scanners are the Phase-companion scanners, which acquire data much quicker by measuring the distance between the emitted laser and the return laser pulses. While a phase-companion scanner captures data rapidly, due to the faster collection speed, this type of scanner can create considerably larger amounts of data than a terrestrial scanner in the same amount of time, which can prove difficult in post-processing.

LiDAR

Similar to both the Terrestrial and Phase-companion scanner is LiDAR (FIGURE 3), which stands for “Light Detection and Ranging.” There are two types of LiDAR, topographic LiDAR, which uses a near-infrared laser to map land features, and bathymetric LiDAR, which uses a water-penetrating green light to measure features below the water surface, such as seafloor and riverbed elevations. LiDAR instruments principally contain three main components consisting of laser, scanner, and a specialized Global Positioning System, or GPS receiver for

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90 Ibid.
capturing the data. Although LiDAR may be used from the ground, aerial vehicles such as airplanes and helicopters are most commonly used for acquiring data over broad areas.\textsuperscript{91}

\textsuperscript{91} Ibid.
APPENDIX B: EQUIPMENT AND SOFTWARE COSTS

PURCHASING A LASER SCANNER

There are dramatic price differences between scanners, most of which comes from the scan range. The Faro Focus X330 sells for approximately $58,000 and has a range of 330 meters, whereas the Faro Focus X130 sells for approximately $45,000 and has a range of 130 meters. In this particular company’s experience, most documentation utilizing scanning falls into the 130m range. This initial cost would cover scanning hardware and the proprietary registration software with one year of maintenance. There is also a handheld unit for capturing short range, small area in higher detail such as ornamental details, such as plaster medallions, which will run approximately $20,000. This cost will also include the hardware and registration software needed to work with the data; however this unit will require a laptop to capture data in the field. A laptop that will operate efficiently, requiring enough RAM, a fast processor, and graphics card will run approximately $3,000, based on email communication with a laser scanning expert. The initial costs are high, and many additional costs come with laser scanning, without which the data would be unusable.

OPERATION, ACCESSORIES AND MAINTENANCE

The following is a basic outline of what the costs for scanning might be as well as some observations about the perception of the associated costs. The initial sticker price of a scanner can be the most expensive cost but operation costs, accessories, and yearly maintenance (including upgrades) represent some of the continued associated expenses. Through communication with a company in New Mexico that utilizes laser scanning for recording, the person interviewed stated that “maintenance for the scanning hardware and registration software will run approximately $3,500 per year after the initial purchase.” Throughout the
interview, this individual reiterated that this maintenance cost is often overlooked by the owner of the scanner, and these increased maintenance fees must be figured into the cost of scanning. For the safe operation of this equipment, less expensive but no less important accessories such as sturdy tripods, registration targets, etc, which are not included in the cost of the scanner must be added as well. This particular recording company in New Mexico recommends having a budget of approximately $5000 to cover these accessories.

The typical data file\(^{92}\) captured by a laser scanner requires a fast and efficient computer to process it. The scanning company in question indicated, they had one computer built in 2011 for approximately $3,000, and with the newer processing software, this unit is no longer capable of meeting current demands. The company is now in the process of upgrading the computer, and received a quote of “$2,800 for that upgrade.” Based on this quote, a typical computer maintenance cost per year would be in the range of $1000. Based on comparable specs of current computers capable of handling these processing softwares, the scanning company stated that to build a new computer from scratch to process this data would run approximately $5,000.

Operation of an actual scanner requires a properly trained technician, which will run between $90- $150 per hour. Depending on what the user wants as a deliverable, a CAD based software such as AutoCAD will run between $4,000-$5,000. Kubit’s VirtuServ Basic, suggested software for the migration of the scan data into CAD, will add an additional $2,500 to the software cost. If the deliverable involves a fly-through, additional video and visualization software must be purchased at an additional cost of $20,000. Processing the data software into

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\(^{92}\) Gigabyte (GB) denotes a digital unit in technology, referencing here in terms of data storage. 
1 GB = 1 000 000 000 bytes = \(10^9\) bytes = 1024 megabytes

Terabyte (TB) denotes a digital unit in technology, referencing here in terms of data storage. 
1 TB = 1 000 000 000 000 bytes = \(10^{12}\) bytes = 1000 gigabytes
some sort of documentation requires software such as Rhino or Geomagic, with the latter running a minimum of $10,000. Clearly upgrade and maintenance is critical to success and excessive costs must be acknowledged when looking into laser scanning. Unfortunately, with the nature of funding for preservation projects, these costs seem to be much greater than the typical budget for most recording.

<table>
<thead>
<tr>
<th>Category</th>
<th>Brand/Model</th>
<th>Cost</th>
<th>Initial Cost</th>
<th>Upgrade with existing license</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Station</td>
<td>Leica Viva TS11</td>
<td>$10,000.00</td>
<td></td>
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<tr>
<td>Laser Scanner</td>
<td>Faro Focus 3D X130</td>
<td>$45,000.00</td>
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<td></td>
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<tr>
<td>Laser Scanner</td>
<td>Faro Focus 3D X330</td>
<td>$58,000.00</td>
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<tr>
<td>Software</td>
<td>AutoCAD 2015</td>
<td>$4,150.00</td>
<td>$2,935.00</td>
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<tr>
<td>Software</td>
<td>3DSMAX</td>
<td>$3,675.00</td>
<td>$2,575.00</td>
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<tr>
<td>Software</td>
<td>Maya</td>
<td>$3,675.00</td>
<td>$2,575.00</td>
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<tr>
<td>Software</td>
<td>Revit Structure</td>
<td>$5,775.00</td>
<td>$4,045.00</td>
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<tr>
<td>Software</td>
<td>Kubit’s VirtuServ Basic</td>
<td>$2,500.00</td>
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<tr>
<td>Software</td>
<td>Geomagic</td>
<td>$10,000.00</td>
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<tr>
<td>Software</td>
<td>Rhino5</td>
<td>$995.00</td>
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**System Requirements for FARO Laser Scanner Software**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Operating System</td>
<td>Microsoft Windows 7, VISTA or XP (Professional, SP2 or higher), 64-Bit</td>
</tr>
<tr>
<td>Processor</td>
<td>At least 1.5 GHz PII (2.5 GHz Multi-Core-x64-processor recommended)</td>
</tr>
<tr>
<td>Memory</td>
<td>8GB RAM</td>
</tr>
<tr>
<td>Mouse</td>
<td>Mouse with 2 buttons and wheel</td>
</tr>
<tr>
<td>Graphics Card</td>
<td>Graphics card with 512MB and OpenGL 2.0 (NVIDIA cards recommended, Quadro class necessary for stereoscopic visualisation)</td>
</tr>
<tr>
<td>Internet Connection</td>
<td>Internet connection for some features required</td>
</tr>
<tr>
<td>Hard drive</td>
<td>Solid State Drive for highest performance recommended</td>
</tr>
</tbody>
</table>
APPENDIX C: Penn State Requirements for B.S. in Survey Engineering

Recommended Academic Plan for BS in Surveying Engineering at Penn State Wilkes-Barre
Effective Fall 2011

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Credits</th>
<th>Semester 2</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDSGN 100 Introduction to Engineering Design</td>
<td>3</td>
<td>ECON 102/104 Micro/Macro Economics</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 015 (GWS) Rhetoric and Composition</td>
<td>3</td>
<td>MATH 141 Calculus II</td>
<td>4</td>
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<tr>
<td>GAGH/GIS Arts/Humanities/Soc Science elective</td>
<td>3</td>
<td>MATH 220 Matrices</td>
<td>2</td>
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<tr>
<td>MATH 140 (GQ) Calculus I</td>
<td>4</td>
<td>PHYS 211 Physics - Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>SUR 111 Plane Surveying</td>
<td>4</td>
<td>SUR 162 Methods in Large-Scale Mapping</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Credits</strong>: 17</td>
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<td><strong>Total Credits</strong>: 16</td>
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</table>

<table>
<thead>
<tr>
<th>Semester 3</th>
<th>Credits</th>
<th>Semester 4</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 230 Calculus &amp; Vector Analysis</td>
<td>4</td>
<td>CMPSC 201C C Programming for Engineers</td>
<td>3</td>
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<tr>
<td>PHYS 212 Physics - Electricity and Magnetism</td>
<td>4</td>
<td>MATH 251 Ordinary and Partial Diff. Equations</td>
<td>4</td>
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<tr>
<td>SUR 212 Route and Construction Surveying</td>
<td>4</td>
<td>PHYS 213 Physics - Fluids &amp; Thermal Physics</td>
<td>2</td>
</tr>
<tr>
<td><strong>SUR 241 Survey Measurement Analysis</strong></td>
<td>3</td>
<td>PHYS 214 Physics - Waves and Quantum Phys.</td>
<td>2</td>
</tr>
<tr>
<td>STAT 401 Experimental Methods</td>
<td>3</td>
<td>SUR 222 Photogrammetry</td>
<td>3</td>
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<tr>
<td><strong>Total Credits</strong>: 18</td>
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<td>SUR 262 Coordinate Systems in Map Projections</td>
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</table>

<table>
<thead>
<tr>
<th>Semester 5</th>
<th>Credits</th>
<th>Semester 6</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CAS 100A/B Effective Speech</td>
<td>3</td>
<td>GAGH/GIS Arts/Humanities/Soc Science elective</td>
<td>3</td>
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<tr>
<td>ENGL 202C/D Technical Writing</td>
<td>3</td>
<td>ECE 302 Engineering Economics</td>
<td>3</td>
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<tr>
<td>GHS Health Science elective</td>
<td>1.5</td>
<td>SUR 362 Geospatial Information Engineering</td>
<td>3</td>
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<tr>
<td><strong>SUR 272 Boundary Surveying</strong></td>
<td>3</td>
<td><strong>SUR 372W Legal Aspects of Land Surveying</strong></td>
<td>3</td>
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<tr>
<td>SUR 341 Adjustment Computations</td>
<td>3</td>
<td>SUR 391 Stormwater Hydrology &amp; Hydrology</td>
<td>4</td>
</tr>
<tr>
<td>SUR 351 Geodetic Models</td>
<td>3</td>
<td><strong>Total Credits</strong>: 16.5</td>
<td><strong>Total Credits</strong>: 16</td>
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<table>
<thead>
<tr>
<th>Semester 7</th>
<th>Credits</th>
<th>Semester 8</th>
<th>Credits</th>
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<tbody>
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<td>GAGH/GIS Arts/Humanities/Soc Science elective</td>
<td>3</td>
</tr>
<tr>
<td>GAGH/GIS Arts/Humanities/Soc Science elective</td>
<td>3</td>
<td>GHS Health Science elective</td>
<td>1.5</td>
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<tr>
<td>SUR 462 Parcel-Based GIS</td>
<td>3</td>
<td>SUR 441 Data Analysis and Project Design</td>
<td>3</td>
</tr>
<tr>
<td>SUR 471 Professional Aspects of Land Surveying</td>
<td>3</td>
<td>SUR 455 Precise Positioning Systems</td>
<td>3</td>
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<tr>
<td>SUR 490 Seminar in Surveying</td>
<td>1</td>
<td>SUR 482 Land Development Design</td>
<td>3</td>
</tr>
<tr>
<td>Tech Elect (*SUR 313 Integrated Surveying)</td>
<td>3</td>
<td>Tech Elect (*SUR 422 Digital Photogrammetry)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Credits</strong>: 16</td>
<td></td>
<td><strong>Total Credits</strong>: 16.5</td>
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</tbody>
</table>

- **Bold type** indicates courses requiring a quality grade of "C" or better
- **Italic type** indicates courses that satisfy both major and General Education requirements.
- **Italic bold type** indicates courses requiring a quality grade of C or better and that satisfy both major and General Education requirements.
- GWS, GHA, GQ, GN, GA, GH, GS, FYS are codes used to identify General Education requirements
- US and IL are codes used to designate courses that satisfy university United States/International Cultures requirements
- W is the code used to designate courses that satisfy university Writing Across the Curriculum requirements
- Y is the code used to designate courses that satisfy the university W and US/IL requirements
- * SUR 313 and SUR 422 are technical electives recommended for SUR E students.

Program Notes:

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