2018

PRESERVATION FOR FUTURE GENERATIONS: DIGITAL TECHNOLOGIES, DIGITALIZATION, AND EXPERIMENTS WITH CONSUMERS AS PRODUCERS OF INDUSTRIAL HERITAGE DOCUMENTATION

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PRESERVATION FOR FUTURE GENERATIONS: DIGITAL TECHNOLOGIES, DIGITALIZATION, AND EXPERIMENTS WITH CONSUMERS AS PRODUCERS OF INDUSTRIAL HERITAGE DOCUMENTATION

By

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A REPORT

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

In Industrial Archaeology

MICHIGAN TECHNOLOGICAL UNIVERSITY

2018

This report has been approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE in Industrial Archeology.

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Acknowledgements

This report would not have been written without the help and support of friends, family, and faculty. First, I must thank Dr. Timothy Scarlett for his dedication to making sure this “non-traditional” student navigated the academic arena. His patience, his belief in my research, and his guidance throughout the writing process made this report possible. Next, I want to thank my committee, Dr. Fredric L. Quivik for his questions, Dr. Eugene Levin for inviting me into the remote-sensing community, and Dr. Sam R. Sweitz for telling me to “hang in there” when I thought the classwork was too difficult. I’m also grateful for the faculty of the Industrial Archeology program who undoubtedly gave me a pass when my 30 years of producing truncated video scripts conflicted with the style of traditional academic writing.

My research topic was generated from all new knowledge gained from attending the Industrial Archaeology program at Michigan Tech and from the cooperation of Dr. Levin and Dr. Yushin Ahn in the School of Technology. Thanks to Dr. Patrick E. Martin and Sean Gohman, I was able to walk on rock piles buried deep in the Keweenaw forests and gain a sense of heritage that I feel can only be gained by time and exposure. Thanks also go to *Geo-Spatial Tea Time* members who welcomed me into their community and helped lug around laser scanners, total stations, and pitched in to document the MTU Power House and Champion #4 shaft house. Bruce Bowditch and Leica Geo-Systems also deserves thanks for volunteering the use and operation of the HDS7000 scanner used to scan the Champion shaft house and the time spent registering the scans. I am also grateful for Nancy Byers Sprague and the MTU Graduate School who allowed me to extend my progress when the realities of health and life interfered.

Lastly, I must thank my family and friends who have listened as I attempted to explain digitalization, industrial archeology, structure and agency, and countless other subjects that were as new to me as it was to them. Their questions helped hone my arguments and for that I will be ever grateful.

Abstract

As digital documentation and recording technologies have evolved, so has the perception that they are segregated and intended primarily for use in either engineering/scientific or amateur/consumer applications. In contrast to this notion, the three-dimensionality afforded by these technologies differs only when considering them in the order of priorities; laser scanners and related image acquisition technologies document and visualize while inversely, consumer cameras visualize and document. This broad field of digital acquisition technologies has evolved into a heterogeneity of tools that all capture aspects of the physical world with a line drawn between them becoming blurred. Within this evolution, these tools are becoming less expensive, easier to use, and depending upon the application, can be operated successfully by individuals having modest or semi-professional skills.

The proliferation of digital documentation technologies, the ease of their use, and the ability to share visual data on the internet allow us to examine the inclusion of digital documentation into the preservation management of historic industrial resource, pushing heritage to the digitalized culture.

CHAPTER ONE: INTRODUCTION

When industries move or go out of business, they tend to leave behind anything that retains little or no salvage value. Not only are these things of little value to the salvors, most of what remains is not unique and can be found at related sites elsewhere. Ironically, the least valuable evidence of past industrial activity becomes the only physical asset left to preserve. Sometimes, communities or governments take responsibility of subsidizing the preservation of the industrial resource because it retains other intrinsic value. If they do not, this paradox poses a dilemma for the preservationists: if the industrial remains were of no value to the original owner, how can a rusting building, or something as benign or ephemeral as a concrete slab or pile of rocks, generate adequate revenue to make the preservation of it practical?

This project seeks to answer the question of what to do with these resources by focusing on the nebulous area, or reality, that exists between the low-value asset and the transformation of it into a profitable heritage site. In contrast to "classic" preservation models that are based on historic significance and supported by grants and public funding, this report argues that digital technologies support the formation of a for-profit business approach that satisfies two main goals: the engagement of the stakeholder community in the identification and preservation of the industrial heritage resources *and* the creation of a digital-business strategy that adds value to those resources and is positioned to compete for visitors (customers) in a digital world. If this can be achieved, a more complete industrial history of the United States can be preserved.

Three technological advancements have aligned that support this argument: *Digitization*, the process of digitally converting traditional forms of information storage, such as documents, images, objects, sound and motion into digital files; a *Consumer as Producer* environment in which members of stakeholder communities are encouraged to produce, broadcast, and publish media products; and *Digitalization*, a technology-centered business strategy that uses the talents of peer communities to focus on problems related to the management of industrial heritage. Together, these three phenomena combine to form a *system* of interconnected elements a heritage organization can use to approach a preservation problem. For example, a stakeholder group decides to open a structure for public tours but must first replace missing windows and repair rotting floors and steps. Rather than depending solely on traditional fund raising and the sales of souvenirs, a call is made to the crowdfunding manager who is asked to initiate a project to make the site ready for public tours. Other members of the peer community are engaged to write an intriguing story that touches people, produce a video that is posted on YouTube, reach out to existing networks, and produce scale models of the structure that are given as perks and awards for various levels of support.

Crowdfunding is a business strategy that connects a global network of people through social media and crowdfunding websites to bring funders and fundseekers together (Gleasure and Feller 2016). Mollick (2016) has identified the advantages of crowdfunding for projects: it establishes a direct connection between the project creator and the funder, enables organizations to attract a substantial amount of funds by raising lesser amounts of money from a larger number of people, and builds a community sense of ownership in the projects people support. Community ownership has advantages that go beyond just raising money. Initiators can reach out to communities to refine ideas and gauge interest, validate demand, build local support. Managers can also seek funds to meet locally-defined goals without compromising with institutional demands from agencies or foundations. Finally, crowdfunding lets the community participate as the ultimate guardians of the heritage product.

1.1 Background

I recently observed the behavior of a multi-generational group of males visiting the Shaft House at the Quincy Mine in Hancock, Michigan. Upon entering the structure, the grandfather marveled at the machinery and the father went directly to a small television that was showing an introductory video/history of the mine. Meanwhile, the two boys were immersed in their smart phones while standing over a 9000-foot-deep mine shaft. It would be easy to blame the smart phones for distracting the boys from the exhibit, but the devices were only doing what they were designed to do: access and deliver information. Ward (2013) sees smartphones as attention magnets unlike any our minds have had to grapple with before. Because the phone is packed with so many forms of information and so many useful and entertaining functions, it acts as what Dr. Ward calls a “supernormal stimulus,” one that can “hijack” attention whenever it is part of our surroundings. Simply hearing a smartphone ring or vibrate, produces a welter of distraction and division of attention. The effect is comparable to books in a library calling visitors out by name and telling why their contents must be read. Unlike any previous technology, cell phones and related devices are designed to actively get attention by buzzing in the owner’s pockets and become addictive. Whether the boys were texting or playing games, their behavior, and to some extent that of the father, raises an important question and a corollary: will future generations continue using mobile technologies and how could this exhibit be enhanced to attract all visitors including those with *and* without any previous experience with industrial machinery and processes?

In a survey published by the American Academy of Pediatrics (AAP), ninety-six percent of children aged one to four had access to mobile devices from age one and 75% owned their own devices (Kabali, Irigoyen et al. 2015). This study also showed that (92.2%) of the 1-year-olds had used a mobile device and that most 2-year-olds accessed mobile devices daily. Another survey by the Kaiser Family Foundation found dramatic development in the growth of access to mobile devices. The survey found that in 2011 38% of all children from birth to 8 years of age had access to a mobile device and this figure rose to 72% in 2013. Even more dramatic, in the same years, growth in 2 year old's usage increase from 10% to 38% (Rideout 2013). Most 3- and 4-year-olds used devices without help and their preferred content consisted of playing games, taking pictures, and watching videos on YouTube and Netflix. As this born-digital generation matures, these trends are likely to compound making people more dependent on social connectivity and digitally-enhanced reality, to suggest, locate and deliver relevant information directly to them via their mobile devices.

Underscoring the impact increased mobile traffic will have on network centers and networking equipment, Cisco Systems, the worldwide leader in Information Technology (IT) projects that the increase in numbers of people consuming data will result in an exponential growth of global mobile traffic increasing sevenfold between 2016 and 2021 for a combined annual growth rate of 47 percent (Cisco Mobile VNI

2017a). Over this same time, the study predicts that society would include 1.5 mobile devices per capita, location-based Augmented Reality (AR) will increase 7-fold, Virtual Reality (VR) will increase 11-fold, and over 75 percent of the world's mobile data traffic will be video. Other studies commissioned by digital-business leaders have confirmed the digital growth phenomenon and are encouraging the business world to re-examine and explore new ways to engage digital customers at every touch-point in the customer experience life cycle.[1] This growth predicts that there will be more digital-customers, but what does this trend mean for managers of a historic industrial heritage site?

Studies by the APP and Cisco predict that 21st century people will live in a digital world and that anything that is not native to that world may effectively cease to exist (Cronon 2013).

Cronon was referring to Google searches conducted by college students but doesn't the same apply to the two boys who only looked up from their phones when they turned to leave the shaft house? The result is the same - there was no substantial engagement with the exhibit – it never existed. Instead of expecting visitors to turn off or ignore their devices, Quincy could produce AR experiences that overlay computer-generated 3D models of missing buildings on the landscape and encourage visitors to view them anytime, and anywhere on the site. An AR app could even be created to "virtually" see into the mine shaft that is inches from their feet.

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[1] Gartner, Forbes, MIT Sloan School of Management, and Deloitte are developing advance management practices in: risk management, financial advisory, free enterprise/capitalism, power of the entrepreneur, and delivers business strategies that optimize IT operations, and create customized digital-business methodologies and frameworks.

AR experiences require 3D models that can be expensive to produce and raises the question of why would management focus so much attention on the younger generation and their relationship with mobile technologies? Experiencing a mine shaft in AR can have children wanting to share their discovery with their parents. The impact of their preferences on their parents' decision-making is tremendous so we should try to pave the way to raise awareness among the youth and present cultural heritage in an attractive and interactive way which is meaningful to them (Moira 2009).

1.2 Research Plan

This report approaches the preservation of industrial heritage as a digital-business process that uses digital technologies and strategies to prepare heritage products for public consumption. Preliminary research discovered that laser scanners and other remote sensing technologies were being used to measure and assess conditions in historic structures and that the data was being viewed as 3D models on computer screens. Interestingly, the data was also being processed into digital media products that appeared on web pages and in demonstration videos posted on YouTube. The duality of these digital technologies to document and visualize prompted the creation of a research plan that investigates the digital links between members of the heritage, remote sensing, and business communities, the internet, the heritage consumer and his mobile devices.

A central tenet to the digital-business approach is the requirement that anything related to the heritage site must be accessible, searchable, and can be shared by anyone over the internet. To account for the variety of two and three-dimensional data that can be collected, the definition of what constitutes a digital documentation technology is expanded to include any technology, and by default, the operators, storage and display, software, and essential parts of the entire socio-technical system.

1.3 Report Organization

Following the introduction in Chapter One, Chapters two, three, and four are devoted to creating an overall impression of how the historic preservation movement, or "industry", is positioned to compete in a digital world. Chapter 2 analyzes a cross-section of industrial history-related websites to assess the structure, types of content appearing on the webpages and assess the skills necessary to produce the media content. The chapter also includes an introduction to three-dimensional recording and modeling that supports the creation of AR and VR applications. In Chapter 3, I report on experiments with consumer and professional survey equipment in archaeological settings. Three case studies examine the application of consumer cameras, laser scanners, and discuss the skills and experience required to perform documentation comparable to the National Historic Preservation Act (NHPA) standards and guidelines. The discussion also considers the types of content and platforms the public is using and reflects upon digitalization, a strategy to attract and engage that public. Chapter 4 examines the transformation that will move heritage documentation from a conventional business model to a digital one that provides new revenue and value-producing opportunities, as well as the challenge of including diverse users into an established management plan. Chapter 5 presents The Virtual Keweenaw (VK) a case study to implement and evaluate the application of digital documentation in a heritage application.

1.4 Conclusion

Digital-business frameworks are supported by three primary pillars – market insight, a collaborative leadership, and one or more technology platforms (Crosland 2018). Insight is gained from having two-way interaction with customers, collaboration with remote sensing and stakeholder groups capitalizes on their combined energies and imagination to collect heritage assets, and digital networks allow heritage managers to become facilitators that connect heritage with the digital public using born-digital business strategies.

Chapter 2: Digital Documentation in the Preservation Communities

"The purpose of documentation is to preserve an accurate record of historic properties that can be used in research and other preservation activities."
Secretary of the Interior's Standards for Architectural and Engineering Documentation

Charles Peterson conceived of The Historic American Building Survey (HABS) to systematically document the built environment of the United States. Peterson saw that fire and the natural elements, demolition, and alteration were destined to wipe out four centuries of buildings from the *old* days.[2] In his proposal to the National Park Service (NPS) in 1933, Peterson, an architect, moved that the survey would be conducted by architects and draftsmen using standardized archival and reproducible recording formats and the results to be archived in the public domain.[3]

As envisioned by Peterson, HABS became a part of the NPS in 1934 followed by the Historic American Engineering Record (HAER) in 1969 and the Historic American Landscapes Survey (HALS) in 2000. Together, HABS, HAER, and HALS are administered by the National Park Service Heritage Documentation Programs (NPS-HDP) with a mandate to collect and archive comprehensive documentation of historic buildings, sites, structures, landscapes and objects to be maintained in the Library of Congress.[4] An abbreviated list of the Secretary of the Interior's Guidelines for

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[2] Charles Peterson referring to the diminishing number of important buildings from four hundred years of architectural heritage. Peterson believed that "it is the responsibility of the American people that if the great number of our antique buildings must disappear through economic causes, they should not pass into unrecorded oblivion." http://www.loc.gov/pictures/collection/hh/background.html#pete

[3] Library of Congress, The Vision of Charles E. Peterson, http://www.loc.gov/pictures/collection/hh/background.html

[4] National Park Service, Heritage Documentation Programs, https://www.nps.gov/hdp/

Architectural and Engineering Documentation is included in Appendix B with full information available on the Federal Register website (Register 2003).

Traditionally, NPS-HDP has defined the standard of documentation and recording of the most important historic sites and large-scale objects in the nation. In 1997 the Library of Congress introduced an online collection, of NPS-HDP resources featuring digitized images of measured drawings, black-and-white photographs, color transparencies, photo captions, written history pages, and supplemental materials. Prior to 1997, the materials in the NPS-HDP collection were only available to researchers who could visit the archives in person or by mail to the Library in Washington, D.C. After, the collection of digital images became accessible to the public, was searchable, and available for download from the Library of Congress HABS/HAER/HALS web site.[5]

Meanwhile, other non-profit/non-governmental organizations (NGOs) and professional associations have created parallel or independent documentation programs and online identities. By determining their own standards and criteria, these organizations have the flexibility to use a mixture of traditional and contemporary digital technologies to capture and display their heritage resources on websites and on-line catalogues. In contrast to only providing access through a physical archive these organizations use their online presence to build membership, recruit students, fundraise, and attract visitors.

In this chapter, I analyze a cross section of preservation-related websites to address two major objectives of digital documentation in the preservation communities. First, I will determine the feasibility of consumers to produce media content published on

[5] Library of Congress, Prints & Photographs Online Catalog, http://www.loc.gov/pictures/

the web pages. Second, I will assess the digital-readiness of the organizations to compete against born-digital enterprises such as Google, Amazon, and Facebook. To reach these objectives, I will assess the types of media including text, graphics and images, the technologies used to create the content, and the skills necessary to operate the technologies. The assessment will focus on the artifacts, like .jpg images, rather than the resources being documented. At the end of the chapter, a digital maturity assessment (DMA) of the organizations will be made by applying criteria commonly used to evaluate businesses in transition.

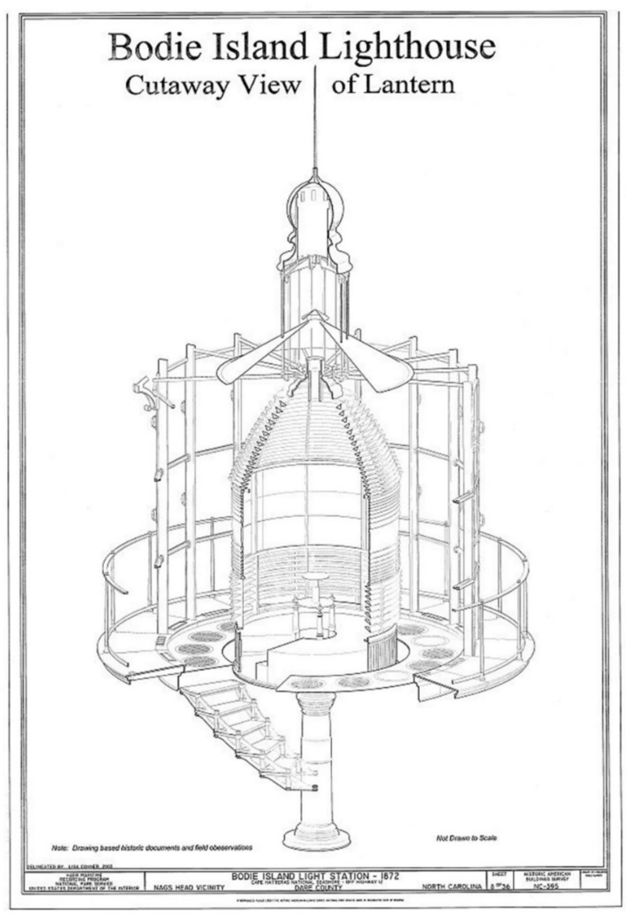

Figure 2.1. Historic American Engineering Survey cutaway drawing of Bodie Island Lighthouse lantern formatted by Todd Croteau. Note drawing is not to scale. (Scan courtesy of Library of Congress, HAER Documentation, Bodie Island Light Station) http://www.loc.gov/pictures/item/nc0497.sheet.00008a/

2.1 HABS/HAER/HALS (NPS-HDP)

Mission- The Library of Congress represents the gold standard in caring for, and providing access to, our important documents, fulfilling the intent of the Historic Sites Act of 1935 and the National Historic Preservation Act.[6] With significant financial and professional resources devoted to curation and presentation to the public, collections are managed to the highest standards to offer the best options for long-term preservation, availability, and usability of mitigation documentation.

The HABS/HAER/HALS collection is no longer simply a resource-based archive, but one of the most popular areas in the LOC's heavily used Prints and Photographs Division. The collection receives nearly 50,000 visitors per month who view approximately a million pages, look at almost 400,000 pages five or more times, and ultimately download nearly 47,000 pages.

Nomination criteria
NPS-HDP conducts a nationwide documentation program in partnership with state and local governments, private industry, professional societies, universities, preservation groups, and other Federal agencies. The program assigns highest priority to sites that are in danger of demolition or loss by neglect, and to National Park Service properties.

Criteria for Evaluation

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or
B. That are associated with the lives of significant persons in our past; or
C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
D. That have yielded or may be likely to yield, information important in history or prehistory.

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[6] Information gleaned from a memorandum from the associate director of Cultural Resources, Partnerships, and Science to Regional Director regarding the transmitting of Library of Congress Mitigation Documentation to HABS/HAER/HALS https://www.nps.gov/hdp/2016MitigationMemo.pdf

Criteria Considerations

Ordinarily cemeteries, birthplaces, graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties *will qualify* if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

a. A religious property deriving primary significance from architectural or artistic distinction or historical importance; or
b. A building or structure removed from its original location but which is primarily significant for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or
c. A birthplace or grave of a historical figure of outstanding importance if there is no appropriate site or building associated with his or her productive life; or
d. A cemetery that derives its primary importance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or
e. A reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or
f. A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own exceptional significance; or
g. A property achieving significance within the past 50 years if it is of exceptional importance.

Sample of Cultural Resources Documented in the HABS/HAER/HALS Collection

HABS

- Pueblo of Acoma Major streets 8 X 10 in. black and white photo
- Frank Lloyd Wright STADTISCHES WOHNHAUS ISIDORE HELLER 4 X 5 in. photocopy
- Old Saum School 5 X 7 in. black and white
- Grist Wind-mills at East Hampton 4 X 5 in. photocopy from illustration

HAER

- Marshall space Flight Center, aerial view 4 X 5 in. black and white
- Bald Mountain Gold Mill Interior 4 X 5 in. black and white
- Statue of Liberty section looking east 24 X 36 in. drawing
- Mesta Steam Engine, The Corrigan, McKinney Company 4 X 5in. black and white

HALS

- Theodore Roosevelt Island, Washington DC, pedestrian bridge 5 X 7 in. black and white
- San Francisco National Cemetery 24 X 36 in. drawing
- The Landscapes of the Battlefield of Franklin, Tennessee 24 X 36 in. drawing

Types of visual media used - Digital images found on the website were available in at least a small and medium-sized JPEG and large TIFF digital file. Information about the item includes the title, creator(s), date created/published, medium, reproduction number, rights or restrictions, call number repository, and place with accompanying (when possible) latitude/longitude.

Purpose of Media- To illustrate, demonstrate, and inform the public of the Heritage Documentation Program and the landmarks that are being documented with laser scanning. Figure 2.2 is a computer aided drawing (CAD) produced from a laser scan that was clipped from a three-minute twenty-two second video containing animated fly-throughs and isometric component drawings derived from those scans.

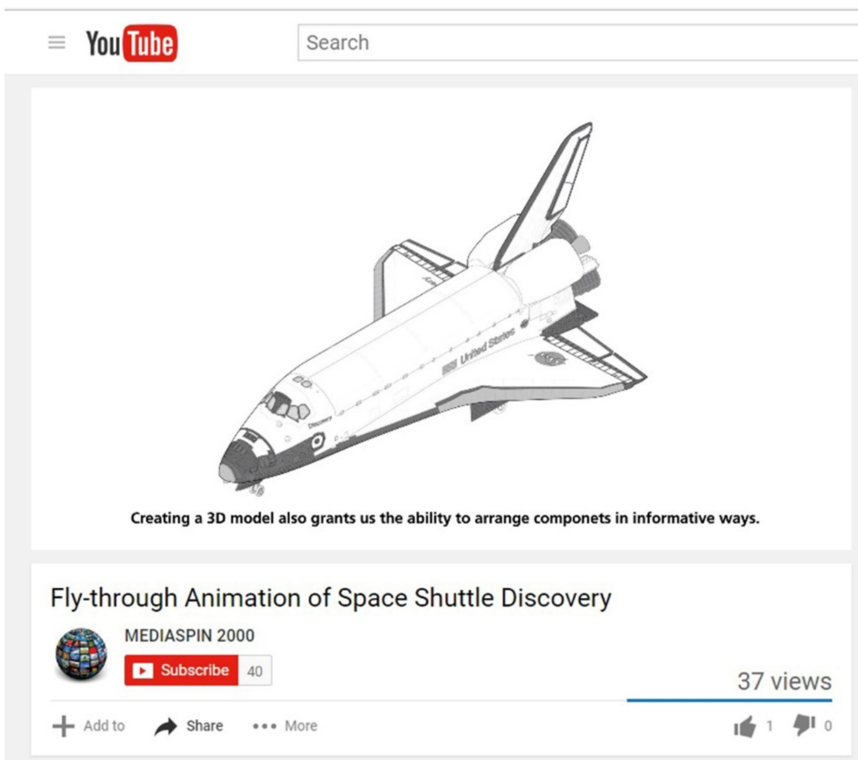

Figure 2.2. Space Shuttle Discovery Cad drawing from laser scan. YouTube Caption: HAER Documentation of OV-103 (Space Shuttle Discovery) (Courtesy HDP. https://www.youtube.com/watch?v=BiHWZhpJoiE&t=4s)

Methods of Recordation- Black-and-white photography, color transparencies, measured drawings, photo captions and written history pages from research.

How are Surveys searched? - The HABS and HAER collections are among the largest and most heavily used in the Prints and Photographs Division of the Library of Congress.[7] The online presentation of the collections includes digitized images of measured drawings, black-and-white photographs, color transparencies, photo captions, written history pages, and supplemental materials. Once on the website, a user may locate documentation of a recorded project by entering the name of the documented resource in a search box. Clicking on an entry, the web visitor is presented a page containing photos, a description and facts about the site, references and other internal links.

Social media- The Library of Congress maintains a website with links to the library catalog, digital collections, research and reference services. The Home Page displays Trending topics, a Calendar of exhibitions and events, and Public domain films from the National Film Registry hosted on the LOC website. The LOC can be followed by email newsletters and alerts, and on Facebook, Twitter, Youtube, Pinterest, Flikr, Instagram, and iTunes.

Other features noted- HDP sponsors several annual competitions to produce measured drawings and the *HALS Challenge* and invites anyone to submit documentation of the historic or commemorative landscapes. The addition of digital documentation by laser scanner has expanded the capability to produce animated three-dimensional sequences and the posting of them on YouTube.[8]

2.3 The American Society of Civil Engineers

Mission- The American Society of Civil Engineers (ASCE), a professional organization, supports the Historic Civil Engineering Landmark Program which recognizes historically significant local, national, and international civil engineering projects, structures, and sites."[9]

Nomination Process- Nominations for inclusion in the National or Local/State Historic Landmark program are submitted to the History & Heritage Committee must come from an ASCE organizational entity or related engineering society.

- Date of construction
- Names of key civil engineers and other professionals
- Historic significance
- Comparable or similar projects, both in the United States and other countries

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[7] http://www.loc.gov/pictures/collection/hh/
[8] HABS/HAER/HALS, YouTube channel, https://www.youtube.com/user/HDPNPS
[9] ASCE, About Landmark Program, http://www.asce.org/Landmark-Program/

- Unique features or characteristics
- Contribution toward the development of the civil engineering profession or the nation
- A list of published references concerning the nominations
- Additional supporting documents (publications, photos, historical evidence,
- The recommended citation for HHC consideration
- A statement of the owner's support of the nomination.

The nomination form also states the name of the site, the latitude and longitude to the nearest minute (or U.T.M. coordinates), plus a detailed local and vicinity map showing road access.

Sample of Civil Engineering Landmarks

- Airports
- Canals
- Dams
- Interstate Highway System
- Long-span bridges
- Rail transportation
- Sanitary landfills
- Skyscrapers
- Water supply
- Water transportation

Once on the ASCE Historic Landmarks web page, a landmark may be located by entering the name in a search box. If the name is not known, search results may be sorted by year completed, location, type, or by name in alphabetical order. Clicking on an entry, the web visitor is presented a page containing photos, a description and facts about the site, references and external links. A random search of civil engineering landmarks on the Landmarks page yields images compiled from Wikipedia and Flicker with photographer credit. Author of text on the site not given.

Media

- Bailey Island Bridge- 1928 480 x 260-pixel .jpg image Courtesy Wikipedia
- Charleston-Hamburg Railroad 1833- No images although many are available on internet
- U.S. Capital- 1800 400 x 253-pixel .jpg image Courtesy Flicker/Matt Mattila
- Ingalls Building 1903- 211 x 400-pixel .jpg image Courtesy Wikipedia
- Lake Washington Canal & Chittenden Locks- 1917 400 x 343-pixel .jpg image Courtesy Flickr/MLS Digital Collection

Types of visual media used - Digital images found on the website were obtained from other web sites and appear to be of at least amateur quality. Image sizes and compression (less than 100kb/image) are fully within the quality that is achievable with any camera or device in production at the time of this writing. Landmark searches are also likely to return a link to the Wikipedia web site, a Wiki site where editing can be controlled or open source, that contains a list of Historic Civil Engineering Landmarks. Each landmark is footnoted with references (citations) titles for further reading, external links, and parks and museums.

Purpose of Media- To illustrate the landmarks

Methods of Recordation- Negative film and color print or black and white and digital camera

How are Landmarks searched? - ASCE publishes *Civil Engineering Magazine* in print and a companion "Digital Edition" that may be viewed online as well. To access the digital edition, an account and login is required with free access for students or annual fee of $225 for licensed engineers. *Civil Engineering Magazine Digital Edition* utilizes 3-D modeling and computer generated illustrations to illustrations.

Social media- The ASCE maintains a Facebook page where a calendar featuring bridge pictures from around the world. A "board" on the Pinterest website provides a map of landmarks from around the world which when the location is clicked, brings up a photo and brief description of the landmark that has been uploaded by the ASCE Foundation and links to others submitted by amateur and professional photographers. ASCE can also be found on Twittter, Google+ and on their own YouTube channel. Generally the ASCE sites include maps, photos, and brief descriptions and historical significance. *Civil Engineering Magazine*, an online magazine, embeds videos and animations within articles presenting new technologies. In the Technology section of the April 2015 edition, researchers from Michigan Technological University were featured using a remotely controlled helicopter drone to take high-resolution photos of roadways. The data collected by the drone was then processed into 3D models and used to detect bumps, ditches, and "washboards" and gain insight into the overall health of the road network with subcentimeter-resolution.[12] Other chapters present Computer Aided Design (CAD) models of proposed projects and a History Lessons chapter in the March 2015 publication showing changes in the Old Cape Henry Lighthouse over time. [13] The ASCE also used 3D visualizations to predict outcomes using stress analysis, underground mine modeling, scanning and modeling of industrial buildings and processes, architectural scans, site surveys, and the detection of changes over time. Mobile versions of *Civil Engineering Magazine* are also available to registered members of the ASCE.

Other features noted- Reinforcing the adaptation of 3-D technologies by engineering professionals, in December of 2015, the ASCE continuing education program sponsored the webinar *Modeling, Design, 3-D Printing of Multiscale Materials and Structures,* a case study covering modeling, design, 3-D printing and material characterization of hierarchical bio-inspired composites. The webinar presented information about the basic technology, techniques and materials, visualization, and the interplay of structure and performance.

2.4 American Society of Mechanical Engineers

Mission- The American Society of Mechanical Engineers (ASME) is another professional organization that awards landmark status to existing artifacts or systems representing significant mechanical engineering technology. Generally, the landmarks are the oldest extant, last surviving examples typical of a period, or they are machines with some unusual distinction. Landmark status is reserved for artifacts, sites, or collections that represent a significant step forward in the evolution of mechanical engineering and is the best-known example of its kind.[14] A plaque is presented for display, a commemorative brochure is prepared, and a roster is kept to promote long-term recognition and preservation efforts.

Nomination Process- Nominations to the Mechanical Engineering Landmarks program may be made by any ASME member having the support of a sponsoring ASME unit. That nomination is then considered for nomination by the History and Heritage Committee. To begin the process four questions must be considered; is the nominated item an example of mechanical engineering (ME), does it represent a genuine advance in the practice of ME, did it make a worthwhile contribution to the human condition, and is it the best example of its kind. The process is relatively straightforward. Nominations are made to designate the engineering work as a Historic Mechanical Engineering Landmark, to be included in the Mechanical Engineering Heritage Collection, or designated a mechanical Engineering Heritage Site. Beside the standard location and statement of ownership, the nomination form requires an argument defending the reasons the subject is being submitted along with other supporting evidence (such as photographs, other illustrations, and documents), specifications, technical description, present condition, modifications, provisions for future preservation, and availability to the public. In their own words, "The Committee is more interested in recognizing mechanical engineering work that has not received prior historical recognition, since this gives the owner of the unrecognized work an awareness of its historical worth and may increase the likelihood that work will be preserved."[15] Upon acceptance of the nomination, the ASME requests a dedication program be sponsored by the owner of the "work" and expects the recipient to:

- Preserve the artifact in the best way possible
- Mount and maintain a plaque
- Make the artifact and plaque accessible to the public
- Offer some hospitality, ceremony arrangements, and brochure preparation

The work is then added to the Landmarks program roster which is kept to promote long-term recognition and preservation efforts.

Sample of Mechanical Engineering Landmarks

- #7 Saugus Ironworks (1647)
- #32 Baltimore & Ohio Railroad Old Main Line (1928)
- #131 Roosa Master Diesel Fuel-Injection Pump (1947)
- #179 Newell Shredder (1969)
- #255 Apollo Space Suit

Type of media used- Black and white images and archival photos, artwork (Saugus), cutaway and exploding engineering drawings and illustrations (Roosa Master and Newell Shredder), color photos (Newell Shredder), and amateur and professional photos from film (Apollo).

Purpose of media- Media was provided to illustrate the appearance and internal design of the landmarks.

Methods of recordation- The 2D images varied from professionally produced photos and engineering drawings to amateur photos taken with film and digital cameras.

How are landmarks searched? Landmarks on the ASME website are searched by designator, topic and location. Searching a landmark returns an abstract pertaining to the landmark, a photo or illustration, and a "brochure" that can be viewed or downloaded and a summary of landmark location, visitor information, related links (web sites) and ceremony notes. The "brochure" generally includes the nomination document with additional photos and historic context. As with the ASCE, a search for Mechanical Engineering Landmarks returns a Wikipedia page with a similar format. Landmarks are sequentially listed with a photo. Each landmark is footnoted with references and external links. The museum also offers family days, guest lecturers, and other activities to attract visitors to the site.

Social media- ASME maintains a Facebook and Twitter account where logged in members learn about upcoming events, share photos, and news-type articles. A sample includes: 3D printed weather stations help farmers predict weather conditions, A new exoskeleton helps children walk, Engineers optimize stadium designs, and Blood delivery drones will be tested at sea. Five of the first ten trending articles dealt with 3D design and printing.

Linkedin- The Linkedin page provides a synopsis of the ASME and links to the organization web site and lists employment opportunities at the ASME.

Other features noted- In 1973, a display at the Metropolitan Waterworks Museum in Boston Massachusetts was the second nomination inducted into the ASME Landmarks program. That display is the Leavitt-Riedler Pumping Engine of 1894 (Figure 2.3). The "brochure" features an animated cutaway drawing, landmark location, and visitor information provided by a link to the Waterworks Museum hosted on the Youtube website.[10] The video includes on-camera personalities describing the museum, historic black and white illustrations/photos, high-definition video recording, and 3D animations.

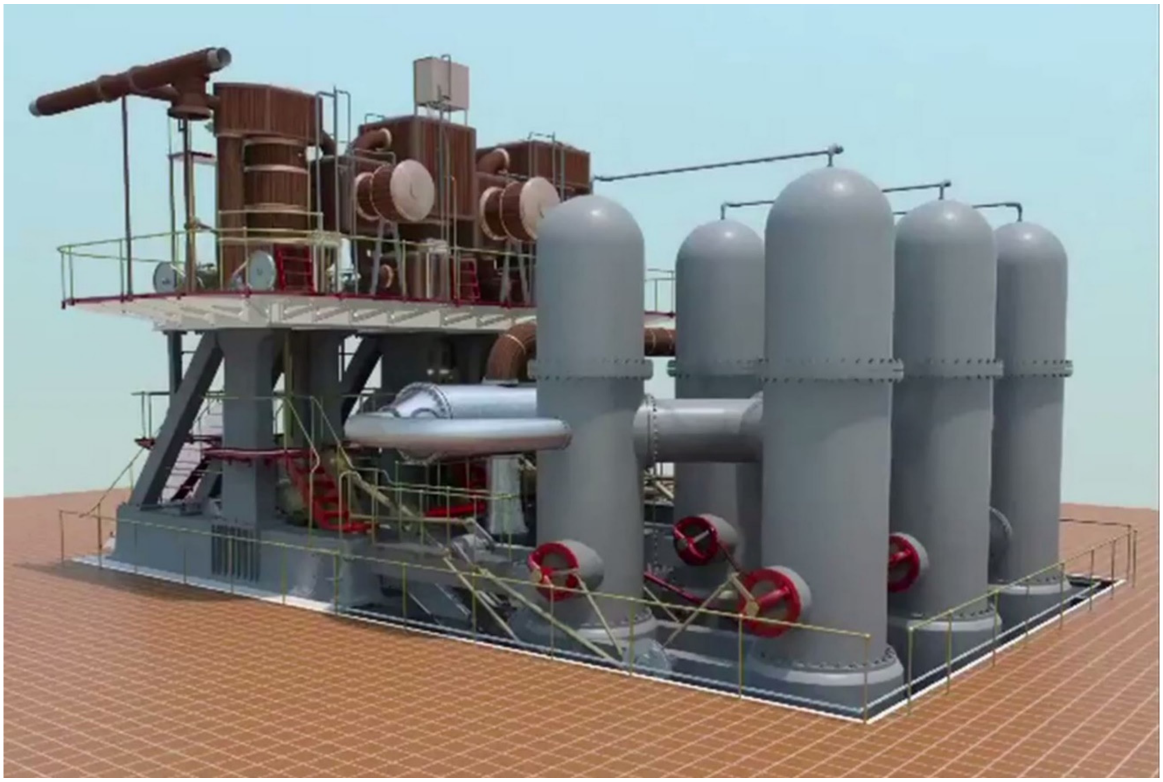

Figure 2.3. Leavitt Steam Engine/Pump still image from animation, (Courtesy John Maggard for Chestnut Hill Museum).

2.5 Cyark.org

Mission- Cyark operates internationally as a non-profit organization with the mission of digitally preserving 500 of the world's cultural heritage sites and create a free, 3D online library that lets current and future generations experience the sites in a way previously impossible. Cyark records heritage sites using (reality capture) technologies 3D laser scanning, and other advanced technologies, to collect engineering-grade data and use that data to create documentation models, drawings, and realistic visualizations for education

[10] John P. Maggard, Leavitt Steam Engine/Pump posted on YouTube https://www.youtube.com/watch?v=2kzcEAG5TZ4

and interpretation. As of this writing, Cyark has completed and archived 40 of the 500 projects and made them accessible to professionals and the public.

Nomination criteria (From the website) - CyArk invites members of the heritage community to submit sites for consideration to be included in the CyArk 500. Interested governments, organizations and individuals are asked to submit a letter of interest. Submissions will be evaluated by the CyArk 500 Advisory Council for selection as part of the 500. Letters that pass the initial review will be asked to submit a formal application for review by the Advisory Council. Selected sites may be eligible to receive digital preservation funding through the CyArk 500 Fund:

- Name, location, and statement of significance for the site
- The relationship of the applicant to the site and site authority
- How and through what authority permissions and access to the site will be granted
    - Risk: the nature and imminence of the threat posed to the site
    - Significance: the position the site holds to the cultural identify of humanity in general
    - Benefits: the positive, far-reaching benefits of digitally preserving the site and transferring technology to the region
- Description of any existing digital preservation data that may be contributed to the CyArk archive
- Description of the nature and completeness of local support for the project including any existing funding to support digital preservation

Note that in all CyArk 500 projects, the site owners and/or site authorities will retain control and ownership of the data collected. CyArk only requests a perpetual license to use all non-sensitive data for non-commercial, public, educational, and research purposes.

Sample of achievements and monuments:

- Mesa Verde – Colorado: On-line 3D point cloud viewer
- Brandenburg Gate – Berlin: 3D rotatable model created from laser scan
- Annaberg Sugar Plantation Windmill– St. John, the Virgin Islands: 3D rotatable textured laser scan
- Lukang Longshan Temple – Taiwan: Panoramic images
- Monastery of Geghard- Armenia:
    - 3D Photogrammetric study of painted Khachkar from Zhamatoun
    - Spherical images from laser scans, hot spots for details, floor plans.

Through 3D documentation, CyArk partners with other heritage organizations to safeguard blueprints of heritage sites and provide opportunities for students and the public to go on immersive virtual tours that showcase the documented site and educational content. For a project using laser scanning to document Mount Rushmore, CyArk cooperated with Scottish Ten, a five-year project, in partnership with the Glasgow School of Art (GSA), funded by the Scottish Government charged with documenting and producing visualizations of five of Scotland's World Heritage Sites and five international sites of similar importance. The data is to be shared with Cyark, a non-profit organization, and with international governments in order to promote interest in global historic monuments.

Generally, Cyark and Scottish Ten showcase their work on their websites with prepared presentations and images that can be right-clicked for saving. Autodesk Design Web Format (DWF) files created from laser scan data can be downloaded and viewed in the free-to-use Autodesk Design Review viewer, some projects include plan and elevation views of selected architectural features, and Cyark posts posts two-dimensional (2D) images of laser scans and maps of sites using DigitalGlobe satellite imagery. To download professional content such as elevation views of the United Methodist church (Figure 2.4) in Adobe Acrobat format, a free account is required that captures the visitor's email address.[11]

Figure 2.4. Deadwood Methodist Church elevation created from laser scan (Courtesy Cyark, Inc.)

[11] Cyark, Deadwood, Elevation of the United Methodist Church's east façade, created from laser scan data. http://archive.cyark.org/elevation-of-the-united-methodist-churchs-east-facade-created-from-laser-scan-data-media

What visual media is used?

- 3D Point cloud from laser scanning missions (low-point count for viewing only, no download)
- Elevation and plan drawings for viewing or download in DWF
- Computer generated 3D models
- Panoramas
- Perspectives
- Photographs
- Videos – 3D animations, narrated introduction videos

Purpose of media- The Mount Rushmore project provides an example of a heritage site where public access is either difficult or dangerous and often located in remote locations. The cloud of points collected by the laser scanner was overlaid with high-resolution digital photographs to create a photo-realistic 3d model that can produce still images of any part or viewpoint of the sculptures. Visualizations, fly-throughs, and cross-sectional views allow "virtual" access to protected areas that would be impossible to see otherwise. Furthermore, where important parts of the site are missing, point cloud data may be merged with computer-generated models to allow reconstructions to be built that simulate historic appearance.

Methods of recordation:

- Laser scanning (terrestrial) for point clouds
- Stitched images from laser scans
- SFM/DSM (photogrammetry)
- Video recording and editing (archival photos, artist renderings, recent photos and video)

How are projects searched? Project sites are searched by images that appear when the "PROJECTS" menu is selected from the CyArk homepage. Clicking on an image opens the project page for that site and displays the historical period, geographic location, theme, and *In Depth*, which adds other historical information, and map of the site.

Social media- CyArk maintains facebook and twitter (@CyArk) social media accounts and a YouTube channel (https://www.youtube.com/user/**cyark)** featuring CyArk 500 themed videos.

Other features noted- Partnering with the National Park Service, Cyark supports mobile applications for smart phones and tablets at selected sites offer portable perspectives of heritage sites by delivering panoramic tours, 3D views, and information viewable on smart phones and tablets. A free virtual tour (application) for iphone may be downloaded from the iTunes (https://www.apple.com/itune) App Store that enhances the visitor experience by linking to a virtual tour (figure Mt Rushmore NPS) http://www.cyark.org/projects/mount-rushmore-national-memorial/in-depth and history of the sculptures, images, videos, and presentation of the digital preservation project. A 3D point cloud animation from the laser scanning mission provides a detailed view of the rock faces accessible which could only be accomplished by ropes and ladders. Also from the 3D laser scanning mission, data was used to map cracks in the stone face. Cyark also produces lesson plans and activities teachers may use to engage students in appreciating the importance of their cultural heritage http://cyark.org/education/ .

2.6 Center for Advanced Spatial Technologies- (CAST)

Mission- The Center for Advanced Spatial Technologies (CAST) is a research unit on the campus of the University of Arkansas that focuses on the application of geomatics, GIS, GPS, remote sensing, photogrammetry, geospatial software and systems design, interoperability, and large (multi-terabyte) geospatial databases.[12] In addition to classroom instruction, the facilities are used by undergraduate and graduate students to develop research projects and gain hands-on experience in geospatial technologies.

Sample of Research Projects: Among recent research projects, the staff at CAST has created:

- Seamless, on-line data warehouse
- K-12 GIS education
- Soil survey by remote sensing
- Land-use/cover identification
- Remote sensing for historic resources
- Multi-sensor remote sensing for historic resources

What visual media is used? (Selected examples related to archeology)

- Photographs
- Laser scans
- Video recordings
- Computer Generated (CG) reconstructions

Purpose of media? Students and faculty at the Center for Advanced Spatial Technologies, CAST, have created models of the original excavated artifacts for users to view and interact with in 3D. The site includes an Interactive Viewer using the Adobe Acrobat PDF interface that gives visitors the ability to perform measurements and view cross sections of objects. Digital files may be downloaded in standard 3D formats (Figure 2.5) that are recognized by most 3D modeling and animations packages. The highest resolution models are provided to facilitate detailed metric analysis using any of the free

[12] CAST Main Site, http://cast.uark.edu/

data viewers suggested on the web site.[13] Digital 3D models of buildings on the University of Arkansas campus have been modeled in SketchUP, a free program, for inclusion on Google Earth.

Figure 2.5. Models from the Amarna Virtual Museum are available for download in three formats: VRML, 3D PDF, and OBJ. (Image from website)

The Virtual Worlds project funded by the Arkansas Natural and Cultural Resources Council uses laser scanning to create 3D models of Native American rock art found in bluff shelters located along Cedar Creek, Arkansas. Open to the public, most visitors walk away without finding any of the pictographs and petroglyphs in the complex environment where they were created. To enhance the visitor experience, the project created virtual models using the registered point clouds that can be viewed on a computer monitor. Within these “worlds” the viewer can navigate through the 3D point cloud to highlighted areas that can then be clicked upon and activate a window that provides an interpretation, an enhanced image of the artwork, and a video description played on YouTube.

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[13] Models from the Amarna Virtual Museum are available for download in three formats: VRML, 3D PDF, and OBJ. The models in .OBJ format are available in original or high resolution as well as low resolution with reduced quality. CAST, Amarna Virtual Museum of 3D Models. http://amarna.cast.uark.edu/3dmodels.html

Methods of recordation- Terrestrial laser scanning

How are landmarks searched? Conventional website browser search

Social media- CAST maintains official identities on both Facebook and Twitter.

2.7 Battleship Texas State Historic Site

The Battleship Texas State Historic Site (BTSHS) is a floating museum that is both a National Historic *and* a National Mechanical Engineering Landmark. The ship is docked along the Houston Ship Channel and is the last remaining battleship that participated in both World War I and World War II.[14]

Mission- The Site is one of one hundred and three parks and attractions in Texas promoted by the Texas Parks & Wildlife Department (TPWD). The TWDP's mission is to manage and conserve the natural and cultural resources of Texas.[2]

Site Overview- More than promoting the historical significance of the battleship, BTHSHS is also engaged in a campaign to fund on-going internal and external structural repairs to insure long-term preservation of the exhibit. The long-term goal is to construct a dry berth to provide dry access to repair the outer hull and establish Battleship Texas park. Even with private donations and public monies from the state of Texas, funds are limited to satisfying the short-term goals of making structural repairs to framework supporting machinery and reduce taking-on of water while the ship remains in the wet berth.

Battleship Website-Landing on the Battleship Texas Welcome page, the visitor is presented with an image of the ship, navigation to Maps, fees & Facilities, Tours & Programs, *Getting Involved* (volunteering, donating and ship preservation), History, and Events. Hovering over the ship image initiates pop-ups that load thumbnails of historic photographs, a 360-degree panorama from the deck of the ship, a video link to "BATTLESTATIONS 1944", A RECREATION, and a second video *Battling 100 Years* produced for the 100th anniversary of the ship's commissioning. The page highlights *Things to Do* that include:

- Self-guided and hard hat guided tours
- Confined space rescue training
- Sleep-overs that let visitors sleep in crew quarters and tour parts of the ship closed to the public
- Habitat and history summer camps
- Recurring public events – Pearl Harbor Day, Yuletide Texas

[14] Texas Parks & Wildlife, Battleship Texas State Historic Site, https://tpwd.texas.gov/state-parks/battleship-texas

- Promotion of nearby parks and area attractions

Field trips are offered to school groups who experience World War II on the Home Front by learning about shortages, propaganda, crew life and "doing with what we have".

What visual media is used? Texas Parks and Wildlife maintains a Youtube channel containing PBS television segments, camping, cooking and other outdoor activities, fishing, hunting, news, and uploads of videos supplied from the public. All images presented in JPEG format or photoscans of historic photographs also in .jpg format. Figure 2.6 is a still image from a nine-minute presentation produced by Texas Parks and Wildlife to describe the history and interior of the Battleship Texas.[15]

Figure 2.6. Battleship TEXAS Engine Room. Still image capture from an animation produced from point cloud data collected by laser scanner. Accessed February 26, 2016 https://youtu.be/cdGo-54bknM?t=203

[15] Texas Parks and Wildlife, Battleship TEXAS Engine Room still capture from point cloud animation, courtesy TP&W

Of the offerings, the Battleship Texas website include invitations to:

- Save the Battleship Texas
- Contribute to the Battleship Texas Project: Structural Repairs and Dry Berth
- View 360-degree scenes from the deck of Battleship Texas
- View 3D animation showing construction sequencing and construction methods for the dry-berth intended to preserve the ship
- Build a 3D model of the Texas in Minecraft,
- Read Battleship Texas the subject of Naval Legends,
- Read news reports,
- Watch *Battleship TEXAS Engine Rooms* a 9-minute video showcasing the engines complete with a description of the ship with cutaway drawings, panoramic stitched photos, archival photos, and a five minute 25 second animated segment using laser scan images and colored point cloud to analyze design and operation of the triple-expansion condensing engines and tour the engine room.[3]

Purpose of media- The extensive collection of video programs provides virtual access to the ship and presents prepared information about the many facets of the Battleship and the historical significance it possesses.

The videos make extensive use of:

- Oral histories and interviews
- 3D animation
- Laser scanning
- Point cloud animation
- Amateur and Professional photography and video recording (aerial and terrestrial)
- Archival film

Social Media- The BTSHS maintains a Facebook, Twitter, and Google+ presence on social media. Battleship Texas engages in an active Facebook page for their overnight education program, Hard Hat Tours, and an unofficial page that attracts informal inquiries and member communications. A private post on the imgur.com site provides digital images of the engine room and a link to the laser scan animation posted on YouTube.[16]

Other features:

- Fee schedule
- Public comments posted to the website become a part of the project record.
- Souvenirs available in the gift shops and online-T-shirts & Clothing, Drinkware, jewelry, magnets, posters, and jig saw puzzles.

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[16] http://imgur.com/a/PRaTP

2.8 Website Analysis

All websites are conventional with a brochure-style design containing static information supplemented with news and other dynamic content. Users access the sites by entering an appropriate name or relevant keywords into an internet browser which returns a familiar "home" page with navigation. The media types (Table 2.1), include two-dimensional images, text, document scans, computer graphics, and animations and High Definition videos hosted on YouTube. Excluding research and technical writing, the media content appearing on these web pages can be produced by anyone having access to a computer and/or a smart phone.

Table 2.1. Consumer Devices for Documentation and Asset Collection

	Create Text	Capture Image	Produce Video	Record Audio	Scan Documents	Print B&W/Color	Print 3D	Publish	Website Content
Still Camera		X	X	X	X	X	X	X	X
Video Camera		X	X	X	X	X	X	X	X
Smart Phone	X	X	X	X	X	X	X	X	X
Computer	X	X	X	X	X	X	X	X	X
Document Scanner	X	X			X	X		X	X
3D Scanner		X					X	X	X

Many of the websites have 2D representations from 3D documentation missions that were conducted at historic sites. In the past, performing 3D documentation in the heritage sector was primarily reserved for engineering and scientific applications where the visualizations were merely an aid to locating details within the data point cloud.[17] The frequency of 3D animations, walkthroughs, and downloadable models appearing on the above websites shows this may no longer be the case. All websites in this chapter included 3D content and as 3D documentation and visualization becomes increasingly popular, data collection may become a secondary role.

2.9 Why 3D?

Figure 2.7. Company of ladies Watching Stereo Photographs by Jacob Spoel circa 1859-1860 (Image courtesy, Riijksmuseum)

[17] Point clouds are a large collection of points acquired by 3D laser scanners or other technologies to create 3d representations of existing structures or resources. https://knowledge.autodesk.com/support/autocad/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/AutoCAD-Core/files/GUID-C0C610D0-9784-4E87-A857-F17F1F7FEEBE-htm.html

When the world is reduced to two dimensions, as in 2D art, architectural drawings or blueprints, the human brain is given the responsibility to imagine them in three. Artists and draftspersons have long looked for techniques and hardware to help viewers make that leap as seen in the figure 2.7 where ladies are looking through a stereoscope.

Laser scanning and photogrammetry transcends two-dimensional representations by collecting three-dimensional data that can be viewed as 3D models and environments in both 2D and 3D displays. 3D environments engage the mind by triggering unconscious responses which are closely connected with our emotional selves. Bawa (1993) says, "Some of our most important perceptual skills are based on survival and have evolved over many millennia, which means they bypass our conscious brain and operate at a much faster, subconscious level." In a way 3D is more traditional because it more accurately reflects our everyday experience of interacting with the world. Whether the intent is to simulate walking through the built environment or to view the workings of complex machinery, an application of three-dimensional (3D) visualization allows viewers to experience the environment "virtually" from anywhere within the scene. Virtual realities are three-dimensional, computer generated environments were the person is immersed in the virtual "world" and is able to manipulate objects or perform a series of tasks (Society 2017). Augmented Reality (AR) applications overlay information on the live image supplied by smartphone and tablet cameras.[18]

[18] http://gadling.com/2013/06/13/augmented-reality-app-shows-romes-coliseum-in-all-of-its-glory/

Figure 2.8. iDinosaur book with AR dinosaur. (Image courtesy Carlton Book-AR)

AR-Media is one of many companies that has engineered plug-ins for these programs to create computer-generated simulations of a real or imagined world over an existing “real” object. The dinosaur in figure 2.8 is viewed over a page in the AR book that lets readers bring Jurassic subject matter to life in augmented form (iDinosaur 2013). Geo-location and movement capability can enhance visitor experiences at historic sites by allowing the user to move about the site and experience it in an immersive 3D environment (Figure 2.9)

Figure 2.9. The Roman Coliseum app adds computer-generated architecture to the live view projected here on a mobile tablet (courtesy ARmedia, 2017)

2.10 General Observations

Digital technologies are disrupting traditional methods of documenting and preserving historic sites, structures, and objects. Good or bad, the broad field of digital acquisition technologies has evolved to include a heterogeneity of tools that capture and display aspects of the physical world. These diverse technologies are blurring the line drawn between professional and avocational users. Within this evolution, these tools are becoming less expensive, easier to use, of higher quality, and depending upon the application, can be operated successfully by individuals having modest or semi-professional skills. Outside this evolution, the ability of consumers to produce professional-quality content puts heritage managers in a position of seeing digital disruption as a threat and/or an opportunity.

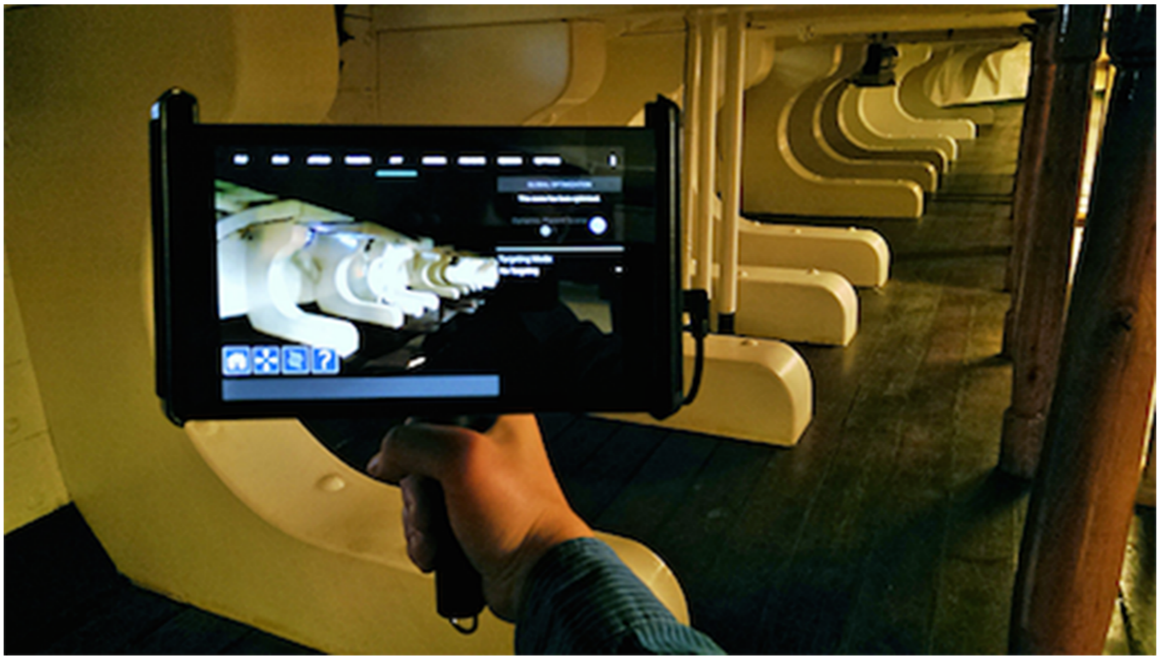

Figure 2.10. U.S. Constitution Scan. DPI-8 requires minimal training to scan and produce animations. http://www.dotproduct3d.com/

In 2015, DOT Products introduced the DPI-8 handheld self-contained scanner and companion software for $7,000. A still image from a video presentation (Figure 2.10) shows a Dot Products DPI-8 being held in one hand as the operator is scanning the interior of the U.S. Constitution. This scanner is based on an Android tablet and is capable of accurately scanning a room and automatically combining the scans into a single 3D point cloud and animate the model using features included in the software. Three-dimensional models can also be produced using photogrammetric and structure-from-motion (SFM) software and consumer-grade cameras and discussed in more detail in next chapter. Three years ago, these tools and processing software were too expensive to acquire and learn without substantial engineering work to justify ownership. Today advancements in the tools, technologies, and automatic registration done in the cloud, any hobbyist can assemble a digital documentation tool kit.

Historically, heritage managers relied on members of professional communities to conduct site work and produce archival reports and content used for websites and promotional materials. Much of the less-critical work can now be accomplished by hobbyists, stakeholders, and volunteers using inexpensive or privately-owned equipment. I would argue that in heritage work, unlike structural engineering for example, the documentation activity becomes less about the monument and more about the digital community and social relationships that are created through documentation projects. At the same time, I also argue that digital technologies can disrupt the marketplace by letting anyone post pictures, videos, and commentary to the internet. This raises a concern that amateur content can create valuable first impressions of the heritage brand. This report is an attempt to show managers and heritage professionals that it is important to transition to a digital-business process that lets them organize consumers to align with preservation goals.

Disruption of traditional documentation is not only about the technologies, it is also about the way people make choices and about the technologies to make choices and in techniques advertisers and businesses implement to influence those decisions. There are metrics that businesses are using to assess the degree of preparation institutions have for dealing with these disruptions.

2.10 Digital Maturity Assessment/Digital-Readiness (DMA)

Findings in a report by MIT Sloan, (George Westerman 2012) revealed that digitally maturing companies are achieving success by increasing collaboration, innovation, and revamping their approach to talent (Kane 2017). Full details of digital maturity are beyond the scope of this study however there are six indicators that can be applied to heritage: Business as Usual, Present and Active, Formalized, Strategic, Converged, and Innovative and Adaptive (Solis 2016a).[19]

All organizations appear to be conducting *Business-as-Usual* or at stage one of the six digital maturity stages (Brighton 2017). At this stage, organizations, through their websites, are operating from a familiar legacy perspective believing it remains the solution to digital relevance. The websites operate with a familiar customer interface, editors anticipate what the public wants and adds new features and content, such as links to videos and drone footage as they become available. Significant changes seem to be mostly technology-driven with content decisions made by the organizations rather than being inspired by customer input.

[19] 1. *Business as Usual* - operating with a familiar legacy perspective believing it remains the solution to digital relevance. 2. *Present and Active* - Pockets of experimentation to drive digital literacy i.e. customer experience research, social media listening identifies gaps in visitor engagement and steps taken to overcome resistance from members and management. 3. *Formalized* - Experimentation becomes intentional having support for additional resources and technology i.e. VR and AR experiences listening and reacting to visitors. 4. *Strategic* - Individual groups collaborate and plan for digital transformation ownership i.e. computer modeling group, VR environment group, and workshop groups. connecting physical and digital. 5. *Converged* - Infrastructure takes shape as roles, expertise, processes and systems support transformation are solidified Digital services and products launched by the stakeholder "network" rather than the top-down hierarchy. 6. *Innovative and Adaptive* - Digital transformation becomes a way of business that recognizes change is constant and acts on changes in market trends.

With the exception that the ASCE invited people to submit personal photos from visits to ASCE landmarks, none of the sites exhibited any effort to be *Present and Active*-which begins the process of identifying gaps in visitor engagement nor any of the four succeeding steps toward digital maturity. Whether leadership rebuffs the need for change or is unaware of the importance of it, the DMA of the sites analyzed here are less-than-mature businesses. A detailed discussion of Digital Transformation is available in Adobe Acrobat from the Altimeter Group website.[20]

In the next chapter I discuss three laser scanning and photogrammetric missions conducted at three historical mine sites. These projects allowed me to observe the introduction of 3D digital documentation into the established fields of archaeology and heritage management, not as a one-time occurrence but as a standard part of research and preservation planning. These projects revealed how technical, economic, social, cultural, and geographical variables influenced this process.

[20] http://www.altimetergroup.com/pdf/reports/Six-Stages-of-Digital-Transformation-Altimeter.pdf.

CHAPTER 3: EXPERIMENTS WITH 3D DOCUMENTATION IN HISTORIC INDUSTRIAL SETTINGS

Figure 3.1. Group of people listening to interpretation at an archaeological excavation. (Image by author, 2011)

"*Archaeologists spend the least amount of time talking about the most important (interesting) thing they do!"* Martin Carver - *Making Archaeology Happen: Design versus Dogma.(Carver 2016)*

Three-dimensional documentation not only offers many benefits for the engineering and survey professions, but also for heritage sites, their communities, and their visitors. Typically, engineering firms commissioned to conduct 3D surveys possess the equipment and technical expertise, but operators are engineers and classical surveyors who may lack a broader knowledge of how their work can impact preservation in the heritage sector. Heritage managers, on the other hand, may not be familiar with the capabilities of

3D documentation technologies and how their deliverables can add value to their sites and on-line and on-site visitors.

The copper mining district of Upper Michigan provides a laboratory-like environment where experiments with 3D documentation can be conducted in historic industrial settings.

This region includes one of the oldest examples of extractive metallurgy on earth and retains the remains of over 400 industrial era mining ventures that people started and abandoned leaving behind mine waste, buildings in ruin, and ephemeral evidence of human activity on the landscape. Three of these sites will receive laser scanning and photogrammetric documentation with the primary purpose of creating 3D visuals like what appears on the websites analyzed in Chapter 2. I chose the sites for their variety, their potential for interpretation and their similarity with hundreds of others found across North America.

3.1 Case Study: Cliff Mine

Figure 3.2. View of stamp mill showing architectural details (Image by author, 2011)

Excavation was concluding on a Cornish-influenced stamp mill that utilized gravity and steam powered milling and ore washing technologies. The architecture shown in figure 3.2 included evidence of extensive modifications made by workers to improve the mineral washing process. The architecture's complexity led the investigators to perform a terrestrial LiDAR survey (TLS) with the expectation that a virtual model will both allow a study of the interrelated parts of the ore-washing technology and provide a quick test of future collaborative opportunities between Industrial Archeologists (IA) and student surveying teams seen in figure 3.3. Motivated by the "wow" factor associated with laser scanning, the students approached the archaeologist who then arranged for a local surveyor to conduct a pro-bono survey.

Figure 3.3. Setup of Riegle long-range terrestrial laser scanner. (Image by author, 2011)

The team was led by a Michigan Tech graduate student experienced with operation of the Riegle LMS-Z210 long range 3D terrestrial laser scanner. As registration targets were being placed, it became apparent that scanner placement would be compromised due to its mechanical design. The 2-meter minimum distance-to-work requirement required the scanner to be positioned away from the edge of the excavation. That limited the scanner's ability to “see” deeper into units and the lower parts of the mill architecture. On the second setup, the laptop power was exhausted requiring the crew to remove the battery from their pickup, rig jumper cables and alligator clips, then complete the remaining four scans. When the data was presented to the archaeologist, he was not aware of how to use the data and didn't have computer software or computer processing power to open the files. The point clouds were eventually registered but with limited detail making the work and model of little use.

3.1.1 Observations

The experience at the Cliff Mine stamp mill was typical of a rescue-type mission when a heritage site is under threat of loss. At the Cliff, the team had only four days to finish a "last chance" effort to document the site before it would be back filled to protect it from vandalism and deterioration. While only some usable data was collected, the attempt to use the laser scanner to document the Cliff Mine mill provided a prime opportunity to observe the engineering and heritage communities meeting across their fields. The experiment clearly demonstrated a lack of communication and understanding of what could be accomplished between the project director and the technicians conducting the scanning mission.

3.1.1.1 Scanner Configuration

The laser scanner configuration (Figure 3.4) limited access to the archaeology. Later, the survey team learned that the scanner could be placed horizontally to view from overhead or inverted 180 degrees and lowered below-grade but survey curriculum rarely taught these uncommon tricks. If the team had the appropriate supporting hardware, this capability would have enabled additional areas to be scanned but would have required erection of additional scaffolding or supports. None of this would have solved the problem of accuracy at close-range as the minimum distance to subject was 2 meters.

Figure 3.4. The laser scanner configuration limited access to the archaeology. (Image by author)

3.1.1.2 Power problems caused unexpected down time

Both computer and scanner relied on an interruptible 12 Volt power source. Without prior planning, allowances were not made to provide an adequate power reserve from batteries or access to portable generator to supply the continuous power needed. When power was lost the scans could not be resumed and were aborted resulting in additional time to collect the data.

3.1.1.3 Data was not delivered in a form the team leader could use

At the time of this mission, the project leader was not familiar with operation of the scanner and the scanner operator did not understand what the archaeologist would do with the collected data. On top of this, the operator subsequently moved away from the area, leaving the equipment to be operated by a survey company who had basic data acquisition training, but not in the data processing. Compounding the problem, the exported files required specific and proprietary software neither of which were compatible with software formats commonly used by the archaeological community.

3.1.1.4 Overselling of the technology

An internet search for laser scanning equipment returns demonstrations and videos that take the viewer around and through point clouds and 3D models predicting a huge WOW factor! In effect, the vendors use the visual output of their instruments to advertise the features and operation of the equipment. Furthermore, heritage managers may also be unfamiliar with LiDAR technical language yet need to initiate conservation measures at their sites *and* consider how the output can assist with marketing and promotion. The solution for these problems is for practitioners to acquire and share knowledge of what digital documentation technologies do and how those abilities can affect the preservation of heritage resources.

3.2 Case Study: Champion Mine

Figure 3.5. Champion #4 Shaft House Painesdale, Michigan. (Image by author)

The Champion Mine Number 4 Shaft House is owned by Painesdale Mine & Shaft, Inc. (PM&S), in Painesdale, Michigan. There is no public access to the site or formal interpretation program, but PM&S arranges chaperoned access to the ground floor upon request. The five-story structure presents significant mechanical and historic integrity as evidenced by numerous line shafts, belts connecting the crushers and hand tools, still hanging where the workman left them after hoisting the last skip of rock in September of 1967. Manual controls are evident throughout the structure, suggesting the mining company made few improvements to modernize the facility through its period of operation.

In phase two of on on-going restoration project, a local engineering firm has been retained to complete a partial shaft house settlement study to assess how soil erosion from beneath the shaft collar is affecting the integrity of the building. A second question addressed deflection of the roof and framework resulting from stresses created by the weight of a man-skip that has been hanging from an overhead beam for 50 years. At the same time, PM&S is soliciting bids and fundraising to measure and restore windows to protect the floors against deterioration from rain and snow accumulation. PM&S was painfully aware of budget limits, as current restoration and conservation efforts are consuming all monies received from membership donations and sales of their popular cookbooks.[21]

Discussions with PM&S confirmed that while they were unaware of how virtual and augmented realities could generate interest and income, they would consider adding digital presentations and related media on their website and social media. To aid their efforts, the primary goal of a laser scanning mission would be to assist PM&S by collecting data to be used for preservation planning and digital products to supplement the shaft settlement study and create media products for public education and interpretation.

[21] http://painesdalemineshaft.com/

3.2.1 The Mission

My initial reconnaissance survey identified types and location of machinery, material handling, production processes, and other material culture important for interpretation. I also made note of missing steps, floor boards, and generated a floorplan sketch to identify possible scanner locations. Bruce Bowditch, Plant Sales Manager for Leica Geosystems, volunteered as a technician and supplied a Leica HDS 7000 phase-based scanner (Figure 3.6) at no cost to PM&S.

Figure 3.6. Leica HDS7000 Laser Scanner in second floor doorway Champion #4 Shaft House. (Image by author 2013)

Leica describes their laser scanning instruments and software product line as High Definition Survey (HDS). Mr. Bowditch approached the mission as a surveyor who had been contracted to scan the building and he took the lead choosing his preferred scanner locations. Acting in the role of the Industrial Archaeologist, I chose additional or alternative scan positions after Bruce had chosen his preferred locations. Any locations that I added were noted as an “Additional” or “Modified” scan to be tallied later to calculate the additional “cost” of my approach. My idea was to determine preferred scanner locations first, to capture pieces of material culture as an archaeologist would document an artifact, and at the same time, capture internal architecture of the shaft house. To capture the exterior of the building, scanner positions were selected to access inside corners and roof architecture with a minimum number of scans.

Operating at eye level, the instrument’s vertical field of view is 320 degrees, collecting a “dome” of points overhead. It has 360 degrees of horizontal revolution and leaves a small shadow directly below the tripod. This radial pattern has two important properties. First, the point cloud is most dense near the scanner and second, lower-resolution data is recommended for scanning at short distances. This knowledge is useful when an archeological mission is planned to capture the interior of a building and details of objects at the same time.

Figure 3.7. Point cloud image from HDS7000 laser scanner. Scanning was performed in a dark environment with no additional lighting. (Image exported from Leica Cyclone 7 software).

Figure 3.7 shows wrenches and other tools near the wall adjacent to the crushers. To capture details that could be visualized in an animation or video, scan density was reduced to collect data with an accuracy of 0.5-1mm. This density was sufficient to let the point cloud appear as black and white historic photographs and result in a smaller file size that is easier to visualize. At the same time, the scanning beam spread to several millimeters at the underside of the roof near the drop hammer pulley appearing in the center of figure 3.8. The higher detail of the pully and bridgework was registered with the lower-resolution scans from around the tool setup to create a complete and detailed model of the complete interior.

Figure 3.8. Point cloud image from HDS7000 laser scanner. Drop Hammer pulley and bridgework. (Image exported from Leica Cyclone 7 software).

3.2.2 Observations

The laser scanning mission at the Champion #4 shaft house was designed to address the problems and challenges experience at the Cliff Mine stamp mill excavation. The Champion project called for collecting interior and exterior three-dimensional data to be archived for documentation, preservation and marketing efforts. The mission goals were to record the architecture, machinery, processes, artifacts *and* other material culture, and then to compare the results with a shaft settlement study that was conducted earlier. At the Champion #4, the two-man team collected 50 interior and 6 exterior scans in 9 hours. In contrast, the mission at the Cliff Mine stamp mill was an open-air excavation not plagued by missing steps, rotting floors, multiple levels, and ladders with loose rungs. The three crew members logged six scans in six hours and 20 minutes.

PM&S received point cloud data that can be referenced and incorporated with existing hand and total-station measurements (Figure 3.9). This includes documentation of all architectural framing in addition to the shaft collars and the interior framing was causing a bulging sidewall near the drop hammer.

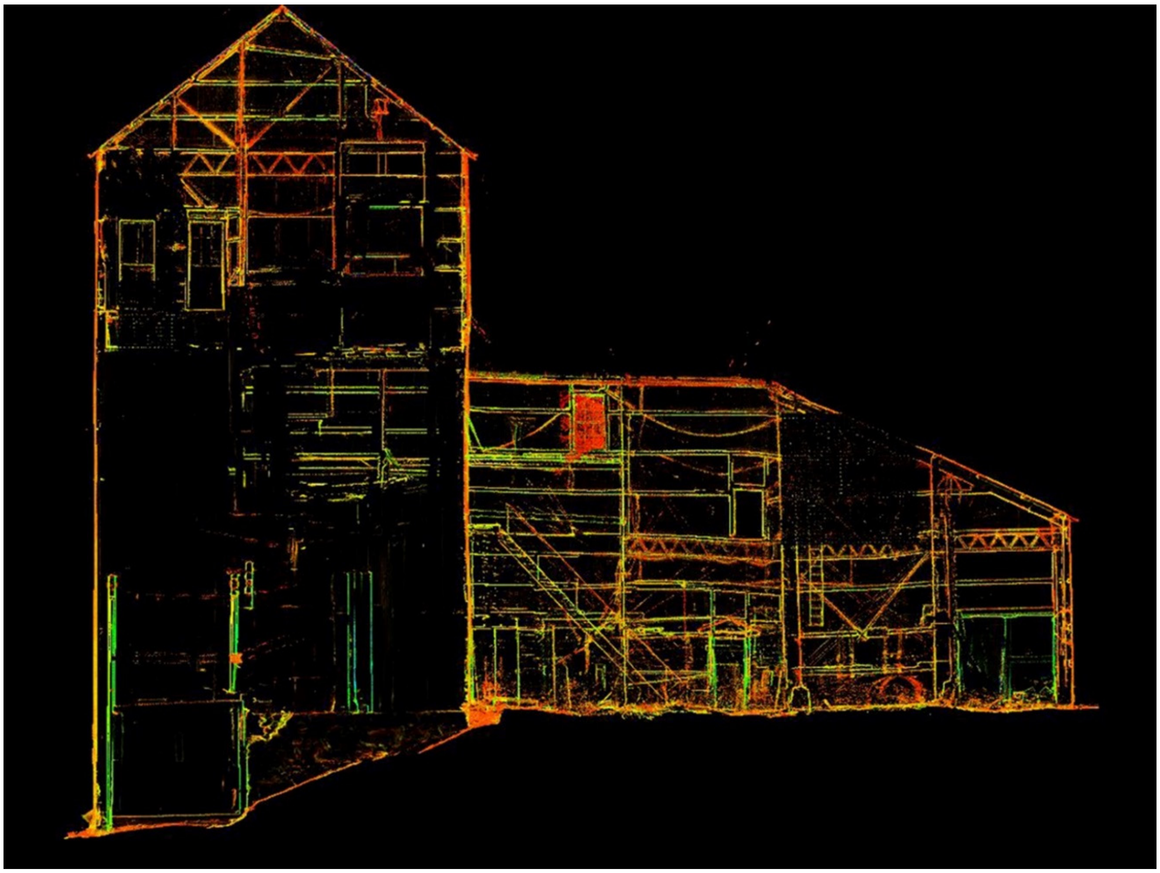

Figure 3.9. Phantom view of interior framing from point cloud image HDS7000 laser scanner. (Image exported from Leica Cyclone 7 software).

3.2.3 Results of Champion #4 Laser Scanning Mission

1. PM&S will have an inventory of windows/sizes to obtain bids on window replacement costs.
2. PM&S has a measure of the decay of elements throughout the Shaft House. The scan also complemented the structural survey by fully recording all internal and external sheathing, rotting or missing floorboards, and steps.
3. PM&S will have of a unified point cloud to be viewed in a point cloud viewer and file conversion for modeling in 3DS Max Design. The survey team also provided cross-sectional images of the shaft house for use in structural analysis.
4. PM&S will receive data in a form that can be used for animated walk-throughs, website marketing, interpretation/education and other products.
5. By repeating a scan later and overlaying one scan over the other, the next survey taken can detect three-dimensional movement in the surfaces by subtracting one complex mesh from another. This provides an invaluable tool for monitoring structural behavior, given that it can be achieved without physical access to the walls.[22]

[22] http://www.merrettsurvey.com/

3.3 Case Study: Pennsylvania Mine

Figure 3.10. The Pennsylvania Mine Hoist House. (Image by author)

In 2012, an archaeological survey crew involved in another project discovered the remains of a structure associated with the North West copper mine in Keweenaw County, Michigan. The ruin was typical of other major industrial structures in the district, being built of hand-fashioned stone blocks laid up with courses of lime mortar. A pedestal set with iron bolts had served as a machine mount. To the side, two tall parallel walls contained long iron bolts sheathed in wooden sleeves and anchored to a wooden beam set into the stone wall. On the exterior, horizontal strips of wood were set into the wall to provide a fastening place for vertical wood panels. Stone from collapsing portions of the structure were relatively close by and of a relatively small volume.

The general appearance and dimension of the structure was unusual among other engine houses found at the contemporary Delaware and Cliff mines. Unlike the other hoists, which had a large engine house with winding drum and divorced boilers, the North West engine house was compact and appeared to have a vertical reciprocating steam engine rather than a beam or horizontal duplex as installed at the neighboring mines.

The Michigan Technical University archives holds few records and little detailed information about the mine. Annual reports and maps drawn in 1863 (Figure 3.11) mention the construction of a steam engine, an engine house, and the indication that an increasing amount of copper was being found.

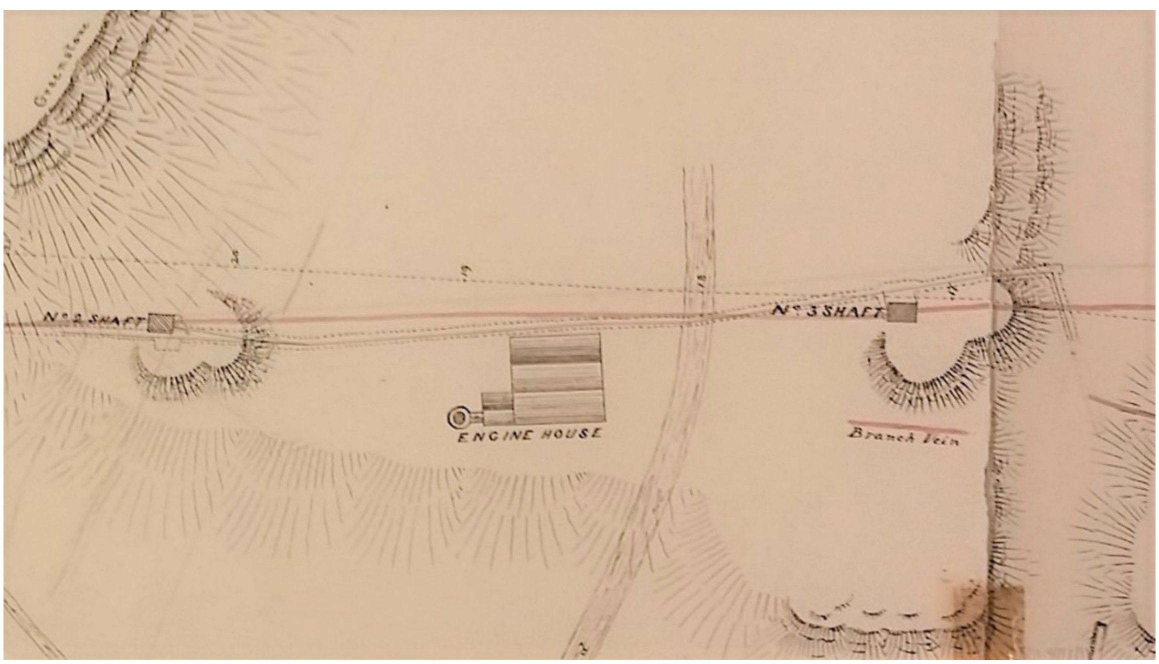

Figure 3.11. 1863 Map showing Engine House from Pennsylvania Mine. Map Courtesy Michigan Tech Archives.

These historical clues seem to suggest the mine is becoming more profitable but reveal discrepancies between the archival information and the physical evidence that remains. I therefore decided to produce a three-dimensional model of the ruin that could be used to both stimulate discussion and study the structure without requiring others to visit the site.

To test the efficacy of using photogrammetry to document a standing ruin, I prepared detailed conventional hand measurements in the field that could later be used to assess the accuracy of a 3D model. The experiment would compare measurements and accuracy taken from the 3D model with those obtained by conventional hand measurement. This photogrammetric experiment would allow me to examine the work flow by observing any distortion or color temperature discrepancies caused by using two different cameras/lenses, by recording the time spent on site, by listing the number of steps encountered from capture to view, by accomplishing the tasks using free or inexpensive software and noting any special skills that were required to use the software or capture the images.

Working alone, I first measured the physical dimensions by hand and created a sketch of the building footprint and elevations of the short walls and engine mount. Due to safety concerns, the height of the tall walls and bolts were only estimated. The time spent conducting hand measurements and production of sketches took one hour fifty-five minutes. Satisfied that I had recorded sufficient measurements were obtained, I began the photogrammetric mission. The mission was planned to simulate two amateur photographers working at various times, with different equipment, and with only a basic knowledge of how the pictures were to be taken for photogrammetric processing.

A Nikon D70 6-megapixel (MP) camera was fitted with a 12X24 Sigma wide-angle zoom lens was used for capturing the east wall, part of the south and approximately half of the interior adjacent to the engine mount. The Panasonic Lumix 12MP camera with a 14X42 lens captured the remaining areas. Both lenses were used in the widest mode and cameras were set to adjust exposure and color temperature automatically. Two hundred and sixty-eight photos were taken within a period of 32 minutes to fully capture overlapping images of the main structure and extending twenty feet or so outside of the building footprint. I captured a second and third series of images with the Nikon to assess the resolution and accuracy of details associated with a wood insert set into the shadowed eastern wall using a manual exposure to compensate for the scene being backlit by the sun.

A series of 250 digital images were selected from the 268 taken with the Panasonic Lumix (12MP/141 images) and Nikon D70 (6MP/127 images) DSLRs. I used Autodesk Memento™, to upload the batch of 250 images to a processing server hosted by the Autodesk™ software company. After an hour and thirty-three minutes, Autodesk automatically prepared a three-dimensional model and notified me that it was ready for download.

In their native state, photogrammetric models are created using a "local" coordinate system that lacks dimensions and orientation. Memento has features to adjust the scale and orientation by entering measurements obtained from points recorded at the site. Using the "Define Reference Distance" option, the hand measured length of the east wall was transferred to the same wall in the model to set the model scale (Figure 3.12).

Figure 3.12. Setting scale of building stone in east wall Penn. Mine. Location pins are place at selected points and the actual dimension is entered into the software. (Image from ReCap software)

The geographic location of the engine mount was approximated with a hand-held Global Positioning System (GPS) sensor and compass. With the scale of the east wall established, the dimensions of the complete model including the south wall, the surface of the engine mount, and height of the interior wall from the beam mortise for example, could be measured.

Dimensional accuracy is generally dependent upon the pixel density of the digital image and the construction of the underlying mesh created by the photogrammetric software. In practice, images taken at greater distances from the subject will result in less dense pixel resolution and increased difficulty to find exact points. National Instruments (2014) has prepared a document describing sensor resolution and focal length but for this discussion, the effect is demonstrated when examining details of the wood inserts in the full model in figure 3.13. Note that the photogrammetric model for the following series was captured with a twelve-megapixel sensor of a Panasonic Lumix G2 camera through a 14mm wide-angle lens operating in the autofocus mode.

Figure 3.13. Pennsylvania Mine Engine House east wall Panasonic Lumix G2 from 20 feet (Image from Autodesk Recap by author, 2015)

Figure 3.14. Pennsylvania Mine Engine House crop of boards from figure 3.12 taken at 20 feet with Panasonic Lumix G2. (Image from Autodesk Recap by author, 2015)

Figure 3.15. Pennsylvania Mine Engine House crop from series of images taken at 3 feet with Panasonic Lumix G2 (Image from Autodesk Recap by author, 2015)

Figures 3.14 and 3.15 show the difference in contrast and detail between images captured from 20 feet with those from 3 feet. A different test conducted with a 24MP Nikon D5200 produced a more detailed model however the purpose of this experiment was to use a camera of "average" resolution so those results will not be included here.

3.3.1 Observations

Fundamentally, photogrammetry is the science of making measurements from a stereo pair of overlapping photographs and outputting maps, drawings, measurements, or 3D models of some real-world objects or scenes (Walford 2017). The most advanced software uses Structure from Motion (SFM) technology that can extract high resolution and accurate spatial data using inexpensive consumer grade digital cameras Micheletti (2015) and is independent of input.[23] Photogrammetry-based software programs mathematically determine internal camera geometry, position, and orientation automatically and without the need for pre-defined "ground control" points. The need for a high degree of overlap is indicated by camera positions in figure 3.16. Photogrammetry provides for very low-cost three-dimensional data acquisition with strongly reduced user supervision, or required expertise, and gives anyone who has basic photographic skills, a digital camera, and SFM software the ability to produce three-dimensional models (CHI 2018).

[23] Cultural Heritage Imaging publishes a detailed account of Structure from Motion citing processes with examples. http://culturalheritageimaging.org/Technologies/Photogrammetry/

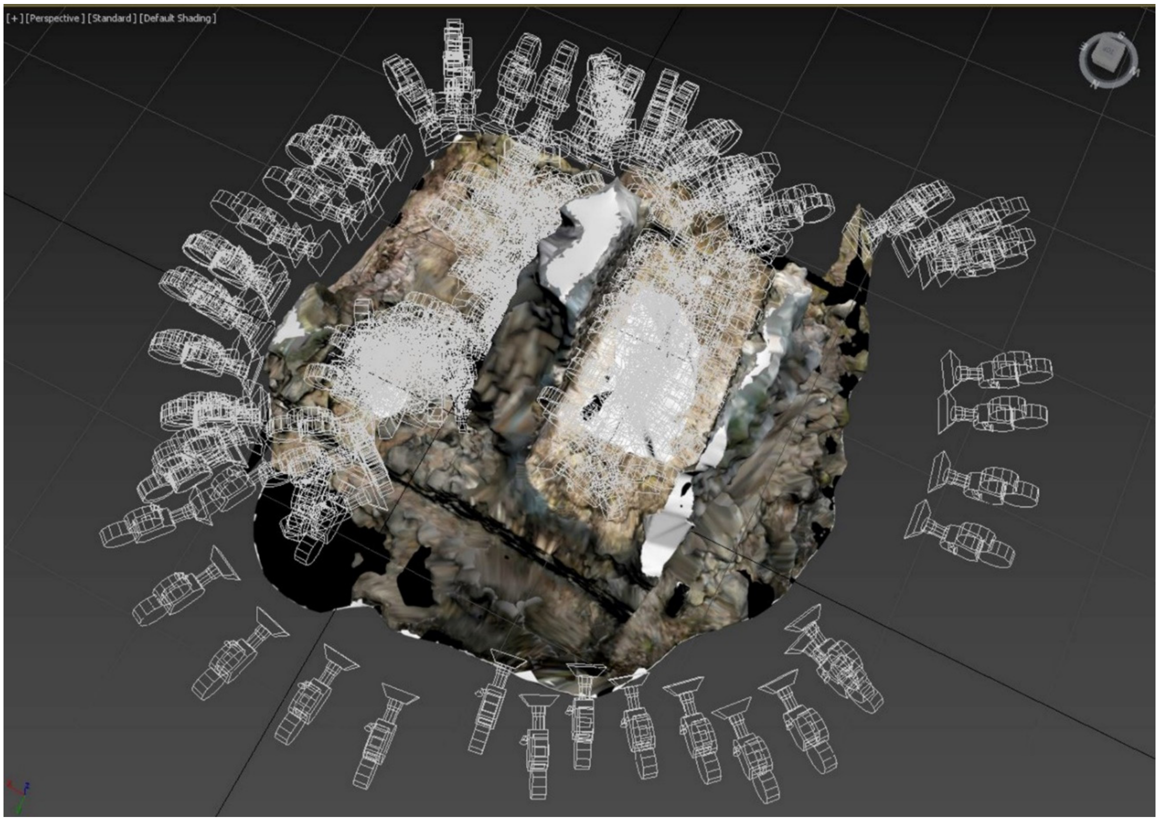

Figure 3.16. Overhead view of Pennsylvania Mine Engine/Hoist house showing software-generated overlapping camera positions

3.3.1.1 Basic Number of steps from capture to view

Six steps are required to complete the production of a scaled 3D model of the Pennsylvania engine house ruin and view the results on a computer monitor:

- Capture a set of overlapping images
- Upload pictures to a processing server (Autodesk 123D Catch)
- Download the model
- Scale, orient, and approve the model
- Export the model to. FBX or .OBJ format
- Open browser (.OBJ plugin required) or Autodesk FBX viewer

3.3.1.2 Time spent on site

The time required to capture 268 images was thirty minutes, including the changes in cameras and lenses. Digital image management, uploading the batch of images, and scaling the final model required an additional twenty minutes or less with most of the time dependent on internet upload speed. This is much less time than what would have been required for me to hand ink scaled drawings or produce native CAD drawings.

3.3.1.3 Distortion or color temperature discrepancies caused by using two different cameras and lens combinations

The model processed correctly with no noticeable difference in point cloud density in areas that were created with overlapping images from different cameras. Color temperature (white balance), as expected, varied between a full color pallet in areas lit by full sun and a bluish cast in shadows which were let by reflected lite from trees and the blue sky. Ideally, all views of 3D models will look the same when rotated. Smaller objects can be photographed in a studio under controlled lighting; larger objects, like buildings, can be photographed without shadows, on cloudy days, or color balance must be set to correct for shadows. Ken Rockwell has an excellent discussion of white balance and how to set it on his photo equipment-review website (Rockwell 2006). It is reasonable to expect that using one camera and lens will result in better consistency of the final images and density of the underlying mesh.

3.3.1.4 Scale and Dimensional Accuracy of the Pennsylvania Mine Model

Measurement points were selected by magnifying and rotating the 3D model to locate arbitrary points on corner stones. Using the length of a stone in the east wall as a scale and reference, measurements were taken in three axes: width of east wall, length of south wall, and distance from ground to beam pockets in interior wall. All dimensions on the 3D model were accurate to within plus or minus one inch (3cm) of the measurements taken with a 30’ metal tape. The roughness of the stones made a perfect measurement difficult, so I averaged the length of the east wall to be 24’ ¼” (288.25) The average length taken from the scaled model was 287.67 inches 24 feet one-half inch.

3.3.1.5 Errors

Photogrammetric anomalies and holes will occur when the software find no image or the algorithm is unable to find matching points. Figure 3.17 shows what can happen when the software was unable to find any information that would cap the corner feature of the Pennsylvania ruin. Without any images to account for the void between the wall surfaces, the software pulls background information, like trees or the sky, or leaves holes which become a permanent error in the model. Recent versions of the software give users tools to edit spikes and fill the holes to make the model “watertight” for 3D printing.

Figure 3.17. shows artificial “spike” created from background image of tree trunk appearing in background

Occlusions such as trees, fences, or brush between the camera and wall will become part of the wall image and contribute to spatial accuracy. For example, a brick obscured in one image will be visible in the next and so on. When the images are processed the software will be "looking" for the brick in numerous images and if it is not "seen" the area where the brick should be may have a ghost of the occlusion. I recommend taking a computer and 3DF Zephr (3DFlow 2018) into the field to build test models before an actual project is undertaken.

3.4 Accuracy and Precision in Documentation Practice

The image and data collection accuracy of laser scanning and photogrammetry generally meets or exceeds the standards established by the Secretary of the Interior for the Heritage Documentation Programs. Plans, elevations, and sections for HDP projects are typically measured by hand and to the nearest 1/8" of an inch (3.175mm) from point to point or point to boundary (HDP 2017). The 3D horizontal/vertical position accuracy of the Faro S-series laser scanners is 2mm at 10meters, 3.5mm at 25 meters and range accuracy of 1mm (3mm S-70) (Bergholz 2017).

When someone performs 3D documentation because they want 3D visualizations (VIZ), measurement accuracy becomes a secondary issue. Looking again at the 3D content appearing on websites in Chapter two, no mention of accuracy was required to help the public understand what they are seeing and at the Pennsylvania Mine, photogrammetry was initiated solely to produce a model for viewing and to stimulate discussions. This does not mean that spatial resolution and accuracy is not important, it means that when 3D images are used to promote and interpret historic resources, the accuracy of the images as representations of actual resources becomes a priority.

Spatial resolution and measurement accuracy of photogrammetry depends on many variables but achieves comparable results to laser scanners under similar conditions. The dimensional accuracy reflected in the measurements at the Pennsylvania Mine is reliable because I see similar accuracies in the analysis of a power plant building on the campus of Michigan Tech (Dice 2016).

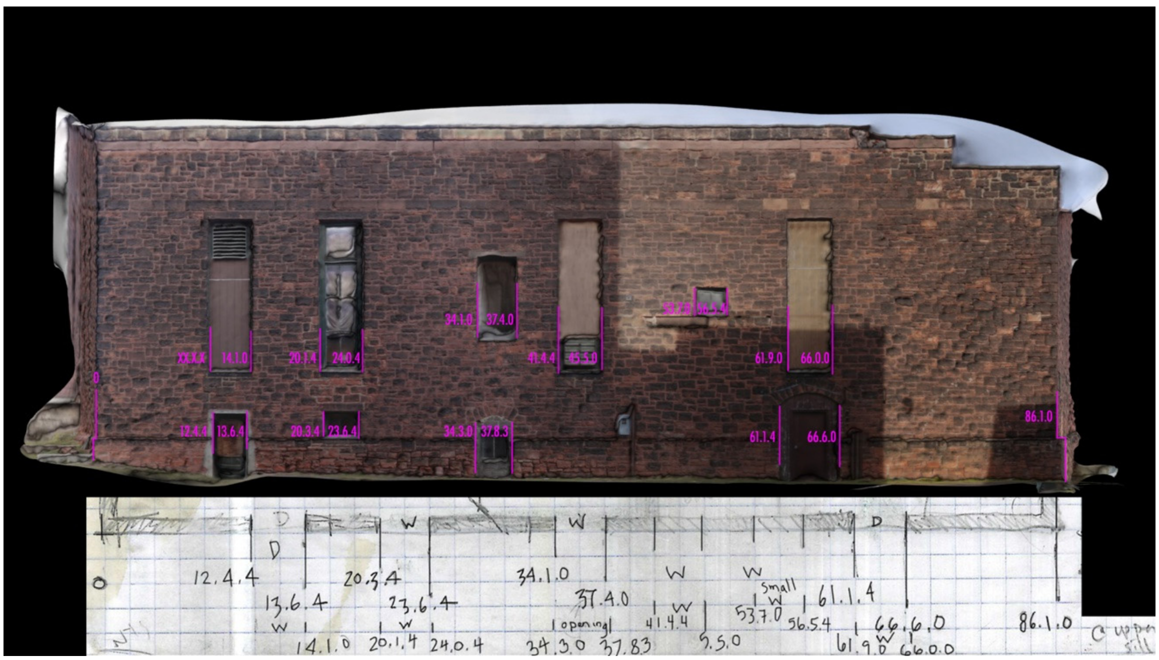

Figure 3.18. MTU Power House east wall measurements (Image by John Arnold, 2016)

In figure 3.18 running measurements are overlaid on an orthographic projection of the east wall. The accompanying table 3.1 compares the measurements from the tape and those extracted from the 3D model in Autodesk Recap.

Table 3.1. Comparison of hand-measurements with Photogrammetry at MTU Power House, 2016

Opening	Hand Measure	Photogrammetry	Difference
First Doorway (RH Side)	13.6.4	13'6 7/8"	+ 1/2"
Basement Window (LH)	34.3.0	34' 1 ¾"	- 1 1/4"
Basement Window (RH	37.8.3	37' 8 5/8"	+ 1/2"
North Door (LH Jamb)	61.1.4	61' 1 7/8"	+ 1/2"
North Door (RH Jamb)	66.6.0	66' 6 5/8"	+ 5/8"
North Wall	86.1.0	86' 1"	+ 0"

Architectural hand-measurements in feet, inches and 10ths of an inch. Photogrammetry in feet and inches. Difference rounded to nearest 1/8th inches.

3.5 Conclusion

Consumers have access to technologies that let them produce the types of content they are attracted to on the media landscape. Smart phones allow users to capture and share media, post to websites and share with online communities. Low-cost 3D scanners, automatic point cloud registration and 3D printers enable users to build scale models; support the creation of three-dimensional data for modeling and interpretation; and create a digital record of resources to assist with conservation and maintenance planning. From among these possibilities, in the next chapter I will examine how the creation of 2D and 3D content can become the foundation for building a digital-born business model.

Chapter 4: Digital Documentation and Digitalization

*"**Digitalization** is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business."*
Gartner- Information Technology Research and Advisory Company 2013

The eminent sociologist and planner Manual Castells observed digitalization as one of the – if not *the* – defining characteristics of the contemporary era's new economy, society, and culture (Castells 2009). *Digitalization* is the process of integrating "digitized" information into a seamless end-to-end strategy to engage consumers directly with an experience. I argue that *Digitalization* elevates a heritage site to the position of a networked social leader and positions the site or organization as a portal, or "gateway", to the global and virtual community. As a gateway, heritage organizations with this type of web strategy offers flexibility in how information is collected and distributed. On one hand the site becomes an archive and on the other, a link to related information provided by the public.

The seeds for Digitalization were sewn in the 1990s when purchases and services became available on the internet. E-services and e-commerce reduced the cost of transactions and adjusted customer desires by movement from time and location-based activities to nonlocational and nontemporal behaviors (Watson 2002). The evolution of e-services is significantly impacting customer and market behaviors with most firms developing functions to automate, "informate", and transform customer relationships and marketplaces (Taherdoost 2013). In other words, customers are using the new digital technologies to produce and consume services without direct personal contact with companies. For Van Dijk (2005), this is significant because for the first time in history, a single communications infrastructure links all activities in society.

4.1 Trends and Predictions

By 2021, 20 percent of all activities individuals engage in will involve at least one of the top seven digital giants: Google, Apple, Facebook, Amazon in the U.S. and Chinese firms Baidu, Alibaba and Tencent (Gartner 2016b). Cisco predicts smart phones traffic to increase from 13 to 33 percent in the same time and that over three-fourths (78 percent) of the world's mobile data traffic will be video by 2021 (Cisco 2017b). Heritage organizations wanting to be found in this environment must consider moving away from a traditional way of doing business and toward a customer-centric model that takes advantage of new technologies to remain relevant. Writing for Wired online magazine, Brian Solis believed society had entered a new era of leadership, a new generation of business models, charging behind a mantra of "adapt or die" (Solis 2014b).

Klaus Schwab (2016), founder of the World Economic Forum, believes a Fourth Industrial Revolution is evolving at an exponential rate and is disrupting almost every industry in every country. In conversations with global CEOs, the underlying theme is that the acceleration of innovation and the velocity of disruption are having a major impact on businesses. New patterns of customer behavior, increasingly based upon access to mobile markets, are causing major disruption on the demand side and forcing companies to adapt to the way they design, market, and deliver products and services. To remain relevant in this fourth revolution, the industrial heritage sector must identify the competition, and develop a strategy to become competitive in this environment.

As a group, the generation born between the 1980s and 2000s represents over a quarter of the world's population and are among the most powerful consumers in history (Young 2011). For an ever-increasing percentage of the population that can afford devices and connections, the expectations of this group are being formed by the technologies they surround themselves with as they adapt their lifestyles to each new technological innovation. These people are constantly connected, collaborative, and highly social. They expect brands to offer immediacy and convenience and they will shy away from brands that do not do this. Any heritage organization who wants to plan for this future, must focus on delivering a seamless and meaningful cross-channel engagement model for their stakeholders (Young 2011). If organizations are to survive, they must embrace digital cultures, or they may be left behind.

4.2 Being Proactive

According to Alfrey and Putnam (2003) proactive organizations act in advance of future situations rather than reacting and adjusting to events as they happen. Being proactive and requires the responsible parties to have a working knowledge of what is going on around them, a clear understanding of their goal, and a plan to achieve that goal. Heritage managers can gain insight about the coming digital world from Cisco, the worldwide leader in IT and networking. Cisco's forecast predicts that virtual reality (VR) traffic will increase 11-fold and augmented reality (AR) traffic by 7-fold between 2016 and 2021 (Cisco Mobile VNI 2017a). Gaming is a key application driving VR growth, and VR and AR increasingly drive user communities in medicine, education, retail shopping and tourism. In July of 2016 Niantic released Pokémon Go (Figure 4.1) in the

United States (Pokémon 2016). Pokémon Go is an augmented reality game that uses image recognition and tracking capabilities of smart phones and tablets to overlay virtual characters onto real world scenes. From Pokémon's introduction on July 6 to July 31, the game was downloaded in excess of 100 million times (Molina 2016) with daily usage exceeding that of Snapchat, Tinder, Twitter, Instagram, and Facebook (Moon 2016). A year after introduction, about 60 million people were playing the game each month and one in five of the players opened the game daily (Bhasin 2017).

Figure 4.1. Pokemon Go Character posed in forest scene courtesy of singletracks.com http://images.singletracks.com/blog/wp-content/uploads/2016/07/pokemon_go_mtb2-1200x900.jpg

It is not enough that a heritage organization wants to preserve a historic structure because it reminds members of bygone era. As commendable as it is to want to preserve a site for posterity, the goal is to make the site profitable. A heritage management plan that attends to documentation while ignoring solvency is like a multi-cylinder engine running on only a few cylinders. The engine may continue to operate but will be out of balance as the working pistons must keep the other assemblies in motion.

To be “found” by the “connected” consumers in the new market, heritage web sites must “appear” during online searches. For example, the common brochure-type website is found by entering a name or search word(s) into a web browser and the more accurate the search word, the better the chance the desired site will appear. In the mobile-digital world, consumers are being directed to sites that have been determined by algorithms and application programming interfaces. While the conventional website design requires the visitor to know what they are looking for, the mobile-digital site does not. To wit, what are the chances someone in Sri Lanka is going to search for a Copper Country historic mining site if they’ve never heard the name? Chances are slim, however, they may search for “Copper” and “find” a Copper Country site if it has achieved A high page ranking.

Prior to establishment of the internet, preservationists were limited to reaching their audience through the local media, community meetings, and word of mouth. Reasonably, those with modest budgets concentrated on the local market and obtained regional exposure by purchasing airtime for commercials and alerting broadcasters to special or news-worthy events. Once local markets are saturated, increased marketing efforts are required to attract the attention of people residing outside of the primary marketing area. The internet changed this calculus. In contrast to maintaining a seasonal cycle of advertising and uncertain cash flow, the internet lets managers remain “virtually” open for business every day. Technically, the only requirement to reach the new and expanding global market is the stipulation that information be in digital formats that can be shared on the internet; practically, businesses must think and act "digital first" to take full advantage of this opportunity (Solis 2016b).

4.3 Digitalization and Industrial Heritage Site

The road to becoming a digital-business is plagued with numerous terminology potholes. Some businesses may assume their "wheels" are too small and stay put and others may choose to go fast and lose their loads by trying to arrive at the destination too quickly. Instead of focusing on how deep each pothole is, and how bumpy the ride might be, it is more productive to know the terms, their meaning and develop a strategy to navigate around them.

Digital transformation is a catch-all term that tends to describe the shift from legacy approaches toward working with digital, mobile, and emerging technologies (Terrar 2015). In the heritage sector, this shift calls for a re-imaging of traditional business models and adoption of strategies that use the talents of peer communities to help make decisions, perform work, and guide the future direction of industrial heritage management. The belief is that digital technologies enable the public to have a voice in how industrial heritage is preserved and ways they can be involved.

4.3.1 Assets

In their native state, heritage assets can be classified into three major classes: tangible assets, intangible assets, and liabilities as assets. Tangible assets include the standing structures and displays, photographs, archival documents, and so on. Intangible assets include historic or landmark status, goodwill in communities, brand recognition, and cooperation from stakeholder groups. Business managers using digitalization may even consider liabilities as a kind of asset, liabilities such as an aging building in need of repair or contaminated property in need of remediation. These things can elevate and direct chatter in digital communities, and thus people argue, should be treated as opportunities instead of merely possible costs. In digitized form, assets become searchable and accessible to anyone in the "community".

4.3.2 Digitization

Digitization is the process of digitally transforming assets into digital files. The process includes the technicians and operators; the digital creation, conversion and storage technologies; the intellectual input that initiates and manages the digitization sequences; and includes a method for covering the associated costs. To make this component of digitalization feasible for a heritage site or organization, some of the responsibility for digitizing assets is likely to fall on hobbyists and members of the stakeholder community.

Benkler (2006) argues that avocational and cooperative modes of labor produce economic value that rivals that of nation-states and bureaucracies. Instead of needing direct market incentives to produce cultural and knowledge goods, individuals are creating and distributing digital goods simply through their love of creation, their passion, or just good will. Benkler believes that digital media are ushering in an era in which consumers are challenging information production in domains ranging from professionalized journalism to academic book publishing. Furthermore, by collaborating on large-scale projects, individuals benefit personally by becoming psychologically gratified, cooperative, and team oriented (Brennen 2014).

Figure 4.2. Active copper mining circa mid-1950s screen capture from home movie. Audrey and Attilio Berdusco visit Copper Country in Michigan. From YouTube

By default, these developments can encourage anyone to become a producer. Figure 4.2 is a still frame from a home movie that captured coal smoke from a Copper Country copper mine that was still operating in the 1950s.[24] Here a consumer converted movie film to video and posted it on YouTube. Social networks that broadcast data throughout the system are an excellent example of this phenomenon. Another local historian/hobbyist, Mike Forgrave (2018), created the Copper Country Explorer web-blog

[24] Complete movie posted on Youtube. Public comment identified the Quincy #2 shaft at 00:20 and the Ahmeek #3-4 shaft beginning near the 01:30 mark in the video. https://www.youtube.com/watch?v=YhbSnZtYF64&t=91s

documenting the mining history of the Copper Country and has expanded his offerings to books and maps and has almost 6000 followers on Facebook. Figure 4.3 shows the clean and professional styling of CCE's web pages (Forgrave 2018).

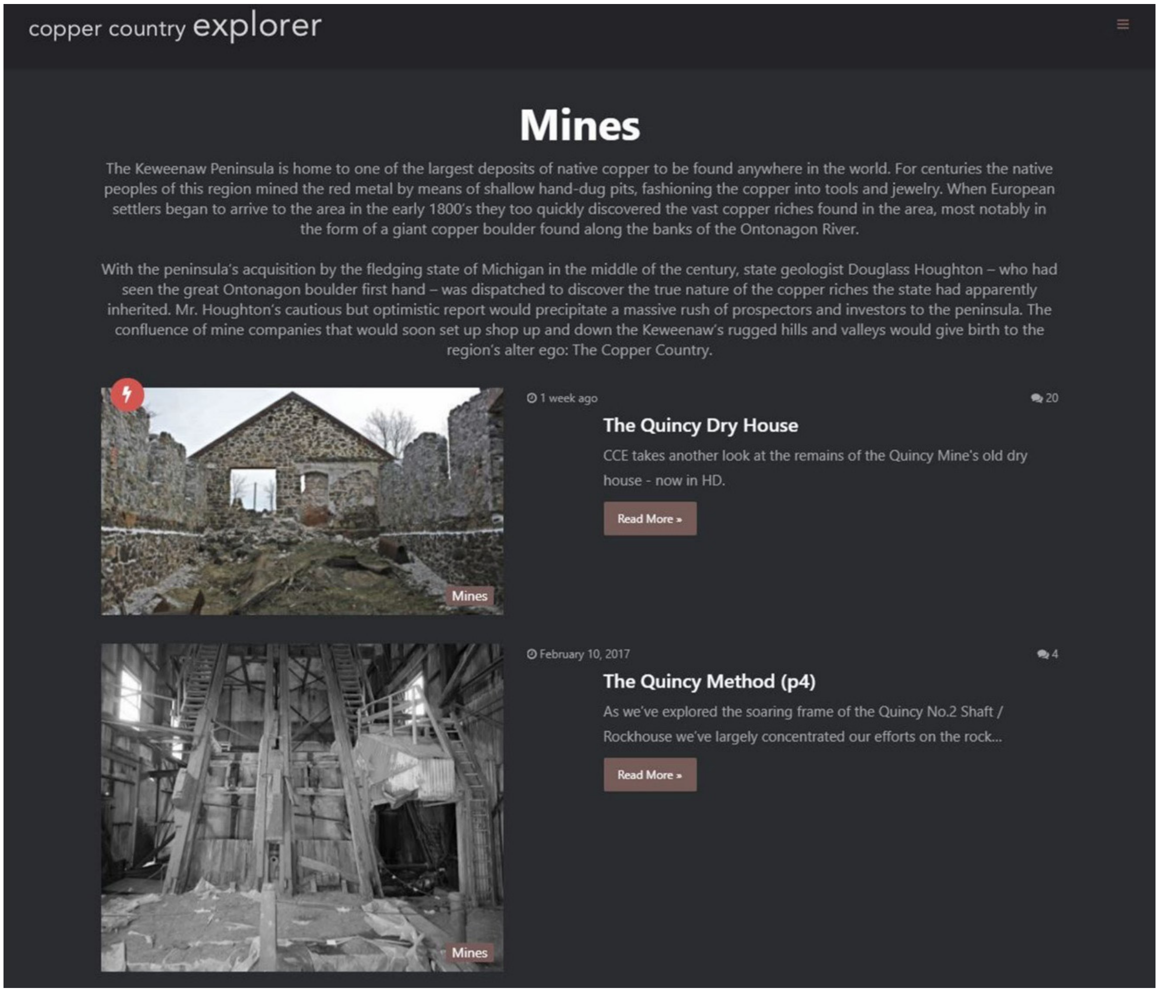

Figure 4.3. Page from Copper Country Explorer website. (Courtesy CCE, 2018)

In contrast to these creative capabilities, there is also the likelihood that information becomes decomposed and irrelevant for the consumer. Like many studies of digital culture, Sandeep Kaur (2015) found that burgeoning social media and user generated content authorizes anyone and everyone to be a fabricator of content without effectual governance. Therefore, to have archival and historic value, it will be necessary to assign some form of gatekeeping or oversight that will direct and supervise any documentary work to verify it adheres to established standards and guidelines. The establishment of a set of standards for documentation by consumers will not be discussed here however, resources are available from the National Park Service (HDP 2017) and a highly detailed set of guidelines for the creation of digital collections is held by the Consortium of Academic and Research Libraries in Illinois (Carli 2017). Heritage managers may also reference the Federal Agencies Digital Guidelines Initiative (FADGI) for best-practices and guidelines for collecting digitized and born digital historical, archival and cultural content on its website (FADGI 2018).

4.3.3 Digitalization and the Web Portal

Digitalization (DZN) is a strategy that adopts recent technologies in Internet Technology (IT) to make the most of the digital resources available in the enterprise (Amarnath 2015). Businessdictionary.com (2014) defines DZN as the: "Integration of digital technologies into everyday life by the digitization of everything that can be digitized." In the industrial heritage communities, DZN brings members of the remote sensing community (laser scanning and photogrammetry), the avocational community of volunteers and hobbyists, and the digital-public together to help make decisions, perform work, and guide the future direction of industrial heritage management. DZN provides the mechanism that routes the public to the heritage assets of interest, content is managed "socially" rather than "top-down" and traffic is increased resulting in more page views and higher page ranking.

Key to the success of digitalization is the creation of a cultural web portal through which heritage organizations can post information, share resources, and cultivate interactive relationships with the public. Portals are specially designed browser-based applications that differ from static websites by providing access to structured *and* unstructured data that enhances interaction in a community of users. Traditional static websites, for example, contain a highly organized or structured collection of facts and this information does not change substantially over time. This contrasts with portals, which contain structured *and* unstructured archival content, proprietary applications, APIs, and functions. The site administrator may then control site access and the visibility of diverse types of content as well as indexing content to be consistent with standard external search engines.

Many web publishers have created new websites or transformed old ones into web portals. For example, DigitalNZ.org, built a portal where visitors can conduct a filtered search of approximately 300 digital collections and contribute material to the collections.[25] The web portal of the United States Government, USA.gov provides access to hundreds of articles about popular government programs and services [26]. All pages contain a search box that works like other search engines such as Google, Bing, or Yahoo. Searches to USA.gov however, only return results from the web pages of federal, state, and local government websites. The video-sharing website YouTube is another portal that makes it easy to share video footage by configuring servers to preserve

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[25] Digital New Zealand, a government-supported Digital Content Strategy begun in 2006 that collects stories/items and shares research. The site brings the wealth of New Zealand content into one, accessible place. https://digitalnz.org/about

[26] USA.gov website, https://www.usa.gov/

compatibility, audits permissions and digital rights management (DRM), provides tutorial videos, and encourages contributors to create channels for receiving feedback and sending notifications to subscribers.

In the first of two examples, imagine that a high school student is allowed access to an archive of historic video clips and photographic images to prepare a video for a class project. Upon completion of their video project the student can add the video to a page on the web portal, perhaps in a section that features videos produced by other local students. In another example, a user could initiate a search for an obscure recipe by entering it as “search” on the web portal. An application program interface (API) routine activates a product discovery capability to access and attempt to make some items related to the recipe available to that user (Amazon 2017). The traffic created by the visit to the video clips and recipes adds to the search engine optimization and social media marketing potential, which in turn helps heritage organizations and stakeholder communities connect in the cloud.

4.4 Conclusion

Cultural studies scholar John Banks wrote that the relationship between media producers and audiences is “undergoing a significant transformation.” Thus the digital world is restructuring and reorganizing fans, consumers, audiences, producers and corporations” (Banks 2002). People are also constantly developing and evolving new platforms and venues for interaction. As H. Jenkins (2006) has observed in his studies of new media, "the roles between producers and consumers are shifting". Audiences are forging a more considerable and noteworthy relationship with media producers, having more choice and influence over which media they consume and how they consume it.

For the first time in history, peer, and the social production and sharing of information, knowledge, and culture is taking shape at a global scale (Benkler 2006). Fans of media products can now interact and discuss their opinions and suggestions with people interested in or involved with that product from all over the world, via online forums, chat rooms, fan sites and mobile phone alerts. Heritage managers can choose to consider the rise of individual and cooperative production as a threat or welcome it as a safeguard against getting lost in the digital-economy. Either way, digital innovation can be very risky and requires investments that may or may not pay off for the stakeholders, but the same can be said for continuing to conduct business as usual.

Chapter 5: Conclusion

In the pre-digital world, industrial heritage organizations had no need to consider the effect smart phones, laser scanners, and globalization would have on their management plans. In the digital world, the image of children texting while they toured an industrial heritage site suggests otherwise. Creating local AR experiences for smart phones, adding social media links and drone videos to websites are improvements, but are indicative of conducting business-as-usual. In contrast, digitally-maturing companies are integrating digital strategies to transform how their businesses work instead of focusing on discrete business problems as they occur.

This report examines the relationship digital documentation technologies have with the creation, preservation, and profitability of historic industrial sites and resources. At an elemental level, digital documentation serves day-to-day functions of prioritizing conservation and maintenance *and* produces two-dimensional images and animated walkthroughs in 3D to be viewed on computers and added to websites. Using this data in dual theoretical roles creates a "loop" in which value-added to the production of marketing visuals offsets the cost of documentation for the sake of history. Being cost-neutral, these one-time events can be initiated at any time and permit a proactive step be taken toward preservation.

Hypothetically, digital documentation and visualization fills a gap between a worth less historic pile of rocks and a viable concern ready to attract investors and traditional preservation-industry support. Conversely, the possibility exists that there is a lack of community interest or initiative to support the endeavor. If this happens, the first goal may be to document and stabilize the physical remains and await a time when their historic value has naturally increased.

Digitalization is part of a digital strategy that gives consumers an active role in shaping organizations and how they respond to consumer input. Several firms and writers (Benkler 2006, Young 2011, Brennen 2014, Gartner 2016b, Solis 2016b) describe digitalization as it applies to enterprise and mainstream legacy businesses, but no mention of heritage sector applications was found. Conversely, Maria Economou (2017) from the University of Glasgow has observed cultural and higher education institutions investing resources on digitization and making their collections available online despite knowing very little about who uses them. Douglas Hegley (2017) of the Minneapolis Institute of Art spoke on digital transformation in the cultural heritage sector making the point that digital transformation is happening and that museums should be prepared to respond. From the business perspective, heritage is currently not a factor and in the heritage community, the professionals and academics are concerned with the influence digital technologies have but are mainly talking amongst themselves on finding ways to respond. To fill this void, and bring attention to this discussion, I have conceived of *The Virtual Keweenaw Project – A Case Study,* to apply the discoveries made in this report to the introduction of digitalization into an active heritage region.

5.1 The Virtual Keweenaw: A Case Study Overview

EXPERIMENTS WITH ALTERNATIVE METHODS OF FUNDING THE PRESERVATION OF HISTORIC INDUSTRIAL SITES USING DIGITIZATION, CONSUMERS AS PRODUCERS, AND DIGITALIZATION

PROBLEM OR ISSUE ADDRESSED:

Research on alternative methods to fund the preservation of historic industrial sites has lagged at a time when costs and competition for grants and monies from private foundations has increased. In the pre-digital world, funding was reserved for sites possessing a high degree of historic significance; in the digital world, sites are free to create their significance because consumers choose social networks and heritage site activities. Technically, the Virtual Keweenaw (VK) project initiates a transformation from a conventional web presence to one that is socially constructed and will automatically adjust to trends and changes in marketplace behavior.

THE STUDY SETTING:

Throughout the Keweenaw Peninsula, there are over 400 mining locations that collectively present examples of cultural diversity, a hostile climate, elusive mineral veins, and remnants of the boom and bust cycle common to other mining districts. Five sites have been chosen to be included in the VK project: The Cliff and Delaware mines, the Champion #4 shaft house, the Quincy Mine & Hoist, and Mine Street in Calumet associated with the Calumet and Hecla Mining Company. To the north, the Delaware Mine operated at the same time as the Cliff and features self-guided tours into the mine that let visitors experience what cannot be seen at the Cliff. The Champion #4 shaft house erected in 1902 contains original equipment and examples of copper extraction processes at the shaft and at the mill in Freda. On a hill overlooking the communities of Hancock and Houghton, the Quincy Mine & Hoist exhibits the most advanced hoisting and ore processing technology being used when mining was discontinued across the region in the 1930s. Mine Street in Calumet exhibits the least physical evidence of mining activity and presents an opportunity to add value to those remains by exploring the production of AR, VR, and video content.

GOALS:

- Develop teams to work with Heritage Managers
- Collect Assets
- Perform Photogrammetry
- Conduct Laser Scanning
- Document and evaluate public participation

Methods:

The design of the VK project differs from a management-does-everything scheme by shifting the responsibility for collecting and formatting assets away from the managers and onto the stakeholder community. Managers will provide input and be a liaison representing interests of the site and collection activities however, any day-to-day management responsibilities will not be affected. The bulk of the "busy work" will be conducted by "others" who invest their time to help the sites succeed. The aim is to build a "network" of volunteers and professionals that will assist in all work and asset collection activities or build capacity among existing volunteer groups.

Sample Initiative and Projects

-Local middle schoolers produce Copper Mining History Mine Tour map and website
-Archaeological studies of worker housing live-cast on YouTube, connected to Chamber of Commerce marketing
-Tracking web data on blog/Facebook
-Collegiate Enterprise Team engineers a web portal
Sample of Deliverables: The VK Project will:
-Perform interior and exterior photogrammetry (3D model creation)
-3D Print a historic landscape (with ruins)
-Produce a 3D walkthrough from a Laser Scan
-Record and edit video segments that document project and personal achievements
-Experiment with constructing AR experience (3D representation of missing building)
-Draft a VR experience with solid models

Evaluation:

To be of use to researchers and heritage professionals, a comprehensive evaluation method will be employed which will calculate the effectiveness and value earned when digitalization is compared to an established benchmark. The study will establish qualitative and quantitative metrics to assess tangible results such as an increase in revenue and if any marginal expenses make it worth the effort. Other non-economic questions will discover any barriers or objections to implementation and measure intangible results by indicating how digitalization affects changes in public perception and participation. Two key issues to observe are the creation of networks and interconnections (linking) between contributors and the public reaction/impact stakeholders can have on preservation of historic properties.

Administration:

Conducted in a series of overlapping phases, the VK project will follow a sequence that can be applied to any historic site at any stage of preservation. The motive is to provide a framework that can be replicated by any type of historic preservation project.

5.2 Report Conclusion

As interest in industrial heritage increases, so does the number of preservationists that are looking for guidance in "doing something" with the historic resources remaining in their communities. Some historic sites may exist only as deteriorating buildings or stone ruins, and some may have nothing more than a concrete slab or a memory. This report approached the question of what can be done to increase the value of historic industrial resources as an industry approaches the question of adding value to raw materials-consider the raw materials as assets, collect them, process them, and market them to the consumers.

Three technological advancements have aligned that can add value to historic industrial resources. Digitization converts traditional forms of information storage, such as documents, images, objects, sound and motion into digital files. Consumers have digital technologies that allow them to join other members of stakeholder communities to produce, publish, and broadcast history-related media products to attract on-site and online visitors. Lastly, digitalization is a technology-centered business strategy that uses the talents of peer communities to focus on problems related to the management of industrial heritage.

Any historic industrial site has the potential to be self-supporting and become an economic driver in the local community. Agreed, not all sites possess or retain a significant amount of historical integrity nor is it mandatory that all sites must be preserved. It does suggest, however, that if the potential exists, all attempts to research and document all available resources must be considered. If they are not, the industrial heritage movement may perpetuate the rise and fall of the industries it has spent so much energy trying to save.

Appendix A

Standards & Guidelines

The **Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation** define the products acceptable for inclusion in the HABS/HAER/HALS collection at the Library of Congress as measured drawings, large-format black-and-white photographs, large-format color transparencies, written histories and descriptions, and field records.
The **Standards** (quoted below) were published in the Federal Register on September 29, 1983 (Vol. 48, No. 190, pp. 44730-34).

Standard I. Documentation Shall Adequately Explicate and Illustrate What is Significant or Valuable About the Historic Building, Site, Structure, or Object Being Documented.
The historic significance of the building, site, structure, or object identified in the evaluation process should be conveyed by the drawings, photographs, and other materials that comprise documentation. The historical, architectural, engineering, or cultural values of the property together with the purpose of the documentation activity determine the level and methods of documentation. Documentation prepared for submission to the Library of Congress must meet the HABS/HAER Guidelines.

Standard II. Documentation Shall be Prepared Accurately From Reliable Sources With Limitations Clearly Stated to Permit Independent Verification of the Information.
The purpose of documentation is to preserve an accurate record of historic properties that can be used in research and other preservation activities. To serve these purposes, the documentation must include information that permits assessment of its reliability.

Standard III. Documentation Shall be Prepared on Materials That are Readily Reproducible, Durable, and in Standard Sizes.
The size and quality of documentation materials are important factors in the preservation of information for future use. Selection of materials should be based on the length of time expected for storage, the anticipated frequency of use, and a size convenient for storage.

Standard IV. Documentation Shall be Clearly and Concisely Produced.
In order for documentation to be useful for future research, written materials must be legible and understandable, and graphic materials must contain scale information and location references.

The **Guidelines** provide advice and technical information on meeting the standards. Most importantly, they outline an approach to historic architecture, engineering, and landscapes that helps ensure the documentation will meet the Secretary's Standards while creating a comprehensive understanding of the site or structure. They also provide recommendations on research methods and report organization, line weight and sheet layout, photographic paper and negative preparation, and the disposition of field notes.

The Guidelines were originally published in the Federal Register on September 29, 1983. A revised version was published in the Federal Register on July 21, 2003 (Vol. 68, No. 139, pp. 43159-43162).

- pdf version of the Guidelines (as published in the Federal Register)
- html version of the Guidelines (Federal Register website)

Appendix B

Secretary of the Interior's Guidelines for Architectural and Engineering Documentation

- **Introduction.** The following guidelines provide more specific procedural and technical information on how to produce architectural and engineering documentation and outline one approach to meeting the Secretary of the Interior's Standards. Agencies, organizations or individuals proposing to approach documentation differently may wish to review their plans with the National Park Service.
- **Definitions**. The following definitions are used in conjunction with these guidelines:
- Documentation—measured drawings, photographs, histories, or other media that depict historic buildings, sites, structures, objects or landscapes.
- Field Photography—photography other than large-format photography (usually 35mm), intended for the purposes of producing documentation.
- Field Records—notes of measurements taken, field photographs and other recorded information intended for the purpose of producing documentation.
- Large-Format Photographs—photographs taken of historic buildings, sites, structures, objects, or landscapes where the dimensions of the negatives are either 4″ × 5″, 5″ × 7″ or 8″ × 10″ and where the photographs are taken with appropriate means to correct perspective distortion.
- Measured Drawings—drawings produced according to HABS/HAER/HALS guidelines depicting existing conditions or other relevant features of historic buildings, sites, structures, objects or landscapes. Measured drawings are usually produced in ink on an archival material, such as Mylar.
- Written Data—inventory forms, data sheets, historical reports, or other original, written works of varying lengths that describe a building, site, structure, object, or landscape and highlight its historical, architectural, technological, or cultural significance.
- Photocopy—a photograph, with large-format negative, of a photograph or drawings.
- Select Existing Drawings—drawings of historic buildings, sites, structures, objects or landscapes, whether original construction or later alteration drawings that portray or depict the historic value or significance.
- Sketch Plan—a floor or site plan, usually not to exact scale although often drawn from measurements, where the features are shown in proper relation and proportion to one another.
- This documentation acts as a form of insurance against fires and natural disasters by permitting the repair and, if necessary, reconstruction of historic resources damaged by such disasters. It is also used for scholarly research, interpretation, and education, and it often provides the basis for enforcing preservation easement. HABS/HAER/HALS documentation is often the last means of preservation of a property: when a property is to be demolished, documentation provides future researchers access to valuable information that otherwise would be lost.

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