From Science to Survival: Using Virtual Exhibits to Communicate the Significance of Polar Heritage Sites in the Canadian Arctic

Abstract: Many of Canada’s non-Indigenous polar heritage sites exist as memorials to the Heroic Age of arctic and Antarctic Exploration which is associated with such events as the First International Polar Year, the search for the Northwest Passage, and the race to the Poles. However, these and other key messages of significance are often challenging to communicate because the remote locations of such sites severely limit opportunities for visitor experience. This lack of awareness can make it difficult to rally support for costly heritage preservation projects in arctic and Antarctic regions. Given that many polar heritage sites are being severely impacted by human activity and a variety of climate change processes, this raises concerns. In this paper, we discuss how virtual heritage exhibits can provide a solution to this problem. Specifically, we discuss a recent project completed for the Virtual Museum of Canada at Fort Conger, a polar heritage site located in Quuttinirpaaq National Park on northeastern Ellesmere Island (http://fortconger.org).

Keywords: Arctic; Heritage, Fort Conger, Virtual Reality, Computer Modeling, Education, Climate Change, Polar Exploration, Digital Archaeology.

1 Introduction

Climate change and the emerging geopolitical significance of the Arctic have important implications for Canada’s polar heritage. In many Arctic regions, thawing permafrost, land subsidence, erosion, and flooding are causing irreparable damage to heritage sites associated with Inuit culture, historic Euro-North American exploration, whaling and the fur trade (Blankholm, 2009; BViikari, 2009; Camill, 2005; Hald, 2009; Hinzman et al., 2005; Morten, 2009; Stendel et al., 2008). These same climate change processes are also making areas of the Canadian Arctic Archipelago increasingly accessible to commercial shipping, oil and gas exploration, and adventure tourism. Canada’s sovereignty over the waterways of the Queen Elizabeth Islands has recently been challenged by nations such as China, Russia and the United States (Coates et al., 2010; Romaniuk, 2013). In response, the Canadian Government has used heritage sites such as the recent discoveries of HMS Investigator, HMS Erebus, and HMS Terror to assert their authority over contested areas (Hodgetts, 2012). The Inuit also have a vested interest in polar heritage, which serves both as sources of cultural identity, memory, and as testimony to the roles their ancestors played in advancing the ambitions of such polar explorers as Robert Peary and Vilhjalmur Stefansson. However, the key messages
that define the significance of polar heritage sites are often challenging to communicate to the public. Heritage agencies such as Parks Canada rely primarily on visitor experience (i.e. going to see a heritage site) to explain the historic events and personalities associated with certain places, and why they have been deemed significant by national and international bodies such as UNESCO World Heritage (Bennet, 1995; Dick, 2008). Unfortunately, the geographic isolation of many polar heritage sites means that many are reachable to only a small number of visitors annually while other locations remain completely inaccessible. Consequently, many Canadians are largely unaware of their existence even though these sites hold an important place in the nation’s history. This absence of first hand visitor experience makes it difficult for heritage agencies to leverage the funding and support necessary for expensive preservation and restoration projects. Virtual heritage offers a potential solution to this problem. Allowing visitors to virtually experience an online computer reconstruction of a polar heritage site, including historic buildings and other cultural features, provides unique opportunities to communicate the key messages used to define their significance.

In this paper, we discuss how reality capture technologies, computer reconstructions, and games are being used to achieve these objectives for Fort Conger; a site of national and international significance located in Quttinirpaaq National Park on northeastern Ellesmere Island (Figure 1). The virtual exhibit is called ‘Science and Survival at Fort Conger’, and it is funded through the Virtual Museum of Canada’s Virtual Exhibits Program (http://fortconger.org). We discuss how the site is an effective way of communicating what life on a 19th century polar expedition might have been like to members of the public. Furthermore, replicating buildings and scientific experiments in virtual reality can provide new insights into the evolution of Fort Conger as a cultural landscape, as well as the challenges of adapting Victorian era technologies to remote regions like the Canadian High Arctic. At the same time, we point out that issues relating to authenticity, the limitations of cyber infrastructure in northern communities, and the need to eliminate barriers to web accessibility present challenges that must be addressed for these technologies to be used to full effect.

![Figure 1. Location of Fort Conger.](image-url)
2 Defining Polar Heritage and its Significance

The Arctic and Antarctic are often viewed as vast, remote, and largely devoid of human occupation. In fact, the existence of cairns, depots, camps, and settlements indicate many centuries of human passage and use of these areas (Barr, 2000, 2004; Barr and Chaplin, 2008; Headland et al., 2004; Kirby et al., 2001). In northern polar regions, the term ‘Indigenous heritage’ is used when referring to the material remains of the activities of Arctic peoples such as the Inuit, Saami, Yukagir, Chukchi, and their ancestors. In contrast, material traces of Euro-North American activities are found in both the Antarctic and Arctic and are denoted as ‘visitor heritage’ by the International Polar Heritage Committee (IPHC), a sub-committee within the International Council of Monuments and Sites (ICMOS) (Barr, 2000, 2004; Barr and Chaplin, 2008; Blanchette et al., 2008). Visitor heritage is commonly associated with the ‘Heroic Age of Arctic and Antarctic Exploration’ – a period encompassing such events as the First International Polar Year (1882-83 AD)\(^1\), and quests for the North and South poles during the first two decades of the 20\(^{th}\) century (Barr, 2000, 2004; Barr and Chaplin, 2008; Blanchette, et al., 2008). Fort Conger, in Quttinirpaaq National Park, Ellesmere Island, as well as the huts of Captain R.F. Scott (north shore of Cape Evans) and Ernest Shackleton (Cape Royds) on Ross Island, Antarctica are well-known examples of these types of visitor heritage (Bertulli et al., 2013; Dick, 1991, 1995; Gibb et al., 2011). Such locations are frequently of modest size and complexity, containing several small wooden cabins or huts (Barr, 2000, 2004; Barr and Chaplin, 2008; Bertulli, et al., 2013; Dawson et al., 2013). At other locations, the remains of factories, machinery, and equipment from the industrial exploitation of whales and seals during the 19\(^{th}\) and early 20\(^{th}\) centuries constitute visitor heritage of much greater scale and complexity (Barr and Chaplin, 2008; Bockstoce, 1986; Burn, 2012). Many contain large numbers of buildings, as well as fuel depots, antennae, dog kennels, and garbage dumps. Examples of these forms of polar heritage include whaling stations, such as Grytviken in the sub-Antarctic (1904-65 AD) (Barr and Chaplin, 2004), and Pauline Cove on Herschel Island in the western Canadian Arctic (1896-1916 AD) (Burn, 2012; Yukon Government, 2013). These sites all share characteristics that set them apart from Indigenous heritage. First, they utilize non-local materials and construction techniques that were subsequently imported into polar environments (Barr and Chaplin, 2004). Second, their occupants engaged in activities that were foreign to many Indigenous groups, such as Western science exploration and industrial scale resource exploitation (Barr and Chaplin, 2004). Third, while Indigenous heritage generally reflects continuity in land use and occupancy, visitor heritage sites were abandoned once expedition objectives had been achieved, resources had been depleted, or mortal tragedies had taken place (Barr and Chaplin, 2004; Bockstoce, 1986; Dick, 2001).

There are few heritage sites in the world’s polar regions that are as rich in history and cultural significance as Fort Conger. Between 1875 and 1935 the site played an important role in several arctic expeditions, especially during the height of the race for the North Pole. While primarily associated with visitor heritage, Fort Conger is also a location where considerable material and cultural exchanges took place between Greenlandic Inughuit and Euro-North American Explorers. The Fort’s evocative remains are spread out across a tableland adjacent to Discovery Harbor on northeastern Ellesmere Island, where they have become a landmark for the few arctic travelers who visit here. Among the cultural relics present are the ruins of the Nares post office cairn, originally constructed from empty food tins; a globe constructed from barrel hoops; a brick instrument pedestal; metal tanks; and two replacement plaques marking the deaths of two seamen from the British Arctic Expedition (1872-73). The building foundation from the headquarters of the ill-fated Lady Franklin Bay Expedition (1881-84), along with the louvers of the thermometer observatory; outlines of tents; barrel water traps; a portable forge; and metal bed stands are numerous and scattered across an area the size of a football field. The three huts built by polar explorer Robert Peary represent the only structures still standing at the site, and have become familiar images of the site.

Like many visitor heritage sites, the material remains at Fort Conger provide important information about the nature of Euro-North American occupations in polar regions. For example, the remnants of

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\(^{1}\) The First International Polar Year was a coordinated scientific exploration of the world’s arctic regions involving 12 expeditions fielded by 12 nations with polar interests.
observatories and scientific instruments are testimonials to the development of global climate science and exploration (Bertulli, et al., 2013; Dick, 1991, 1995, 2001). Furthermore, the material culture present at Fort Conger illustrates how many scientists and Western explorers increased their chances of success and survival by incorporating Indigenous knowledge and technology in their expeditions (Bertulli, et al., 2013; Dick, 1991, 2001). Because of all this, Fort Conger is protected under national legislation. The three standing structures built by American polar explorer Robert Peary in 1900 have achieved the highest level of designation made by the Federal Heritage Buildings Review Office as Classified Federal Heritage Buildings; the same accorded Canada’s Parliament Buildings in Ottawa (Bertulli, et al., 2013). Fort Conger is also one of two places in the Arctic at which the Historic Sites and Monuments Board of Canada (HSMBC) commemorates the First International Polar Year (IPY) of 1882-83 as a National Historic Event (Bertulli, et al., 2013).

### 3 Risks to Polar Heritage

Regardless of these designations and honors, polar heritage sites like Fort Conger are presently at risk because of two interrelated processes associated with climate change (Barr, 2000, 2004; Barr and Chaplin, 2004; Barr and Chaplin, 2008; Bertulli, et al., 2013; Blankholm, 2009; D’Arrigo et al., 2010; Flatman, 2009; Hald, 2009; Helskog, 1988; ICOMOS, 2007, 2008; IPCC, 2007; Kincey et al., 2008; Murphy et al., 2009; Stendel, et al., 2008; UNESCO, 2007; Vallega, 2003). The melting of permafrost and permanent snow pack is thawing organic materials and causing biodegradation through microbial activity and exposure to the elements (Camill, 2005; Elberling et al., 2011; Jorgenson et al., 2009; Lantuit et al., 2012; Murton and French, 1993; Osterkamp and Romanovsky, 1999; Rowland, 2010; Schuur et al., 2008; Smith and Burgess, 1999).

At Fort Conger, this is manifest in the deterioration of heritage buildings triggered by ice, snow, and water accumulation in interior areas, and wind ablation on exterior wooden surfaces (Barr and Chaplin, 2004; Blanchette, et al., 2008). These conditions lead to soft rot caused by fungi (*Cadophora* species) that thrive in the moist conditions and temperatures of a warming Arctic.

Rising sea levels and the effects of large storm surges, produced by changing weather patterns and depletion of sea ice, are also destroying significant numbers of heritage sites in coastal areas through wave impact and erosion (Erlandson, 2010; Flatman, 2009; Kincey, et al., 2008; Lantuit and Pollard, 2008; Mars and Houseknecht, 2007; SCAPE, 2011). At Fort Conger, substantial bank erosion of the tableland on which the site sits presently threatens artifacts and cultural features at the site, including the Nares post office cairn, the Greely station house foundation, and the Peary hut complex. An ongoing monitoring program by Parks Canada reveals that the distance from the northwest corner of the Greely station house to the eroding bank was 11.7m in 2007 and 9.4m in 2010. Especially troubling is the fact that the post office cairn feature is presently only a meter from the eroding bank edge.

Contaminated soils place Fort Conger at further risk of destruction (Bertulli, et al., 2013; Blanchette et al., 2004; Dawson, et al., 2013; ESG, 2009; Gibb, et al., 2011). The scientific work of early International Polar Year (IPY) expeditions required the use of arsenic trioxide to preserve natural history specimens and samples; mercury for weather recording instruments; lead from can solder; and copper and zinc from batteries (Bertulli, et al., 2013; ESG, 2009). The construction of expedition buildings also involved polycyclic aromatic hydrocarbons (PAHs) from tarpaper. The potential uptake of these elements into the terrestrial food chain and migration into the marine environment pose significant risks to nearby plants and animals (ESG, 2009). Inorganic contaminants have been found in several areas where important cultural features are concentrated, including the Greely station house (Bertulli, et al., 2013; ESG, 2009). Other polar heritage sites experiencing contamination issues include the expedition headquarters of Captain R.F. Scott and Ernest Shackleton on Ross Island, Antarctica (Blanchette, et al., 2004; Kirby, et al., 2001; Pearson, Stehberg, et al., 2009; Snape et al., 2002). Removing and disposing of contaminated soils at these sites creates disturbances that places artifacts and buildings at risk of damage and/or destruction.

Damage resulting from wildlife and humans has also been cited as causes for the loss and movement of artifacts and damage to buildings at polar heritage sites such as Fort Conger (Bertulli, et al., 2013). The huts constructed by Robert Peary, for example, have been damaged by polar bears (Bertulli, et al.,
At the same location in 1994, the wing of a chartered fixed-wing aircraft clipped a seven-coursed brick instrument pier associated with the Lady Franklin Bay Expedition (1881-84) (Bertulli, et al., 2013). Likewise, the cumulative impacts of ship-based adventure tourism since the early 1990’s are beginning to impact polar heritage sites in many regions of the Arctic and Antarctic (Hall and Johnsten, 1995; Luck et al., 2010; Notzke, 1999; Roura, 2011; Stewart et al., 2007; Stewart et al., 2013; Yukon Government, 2013). These include the potential for footpath development, littering, appropriation of historic artifacts, graffiti, and the dismantling of historic structures.

4 The Digital Preservation of Heritage at Risk

Considering these factors, the need to preserve and protect polar heritage sites like Fort Conger may seem obvious. However, conservation efforts cost money, and government funds are invariably limited (Fushiya, 2010; Hart, 1994; Jones and Bradley, 1992). Furthermore, difficulties can arise when conservation standards and practices originally developed for use in less extreme environments are applied in the Arctic and Antarctic. The use of reality capture technologies such as terrestrial laser scanning (TLS) has emerged as an effective means of rapidly and accurately recording and digitally preserving artifacts and cultural features in other areas of the world (Ahmon, 2004; Al-Khedera et al. 2009; Armesto-González et al 2010; Barber et al., 2009; Betts et al., 2011; Dawson, et al., 2013; Entwistle et al., 2009; Gibb, et al., 2011; Guarnieri et al., 2010; Kottke et al., 2011; Kuzminsky and Gardiner, 2012; Tapete et al., 2013; Van Genechten et al., 2011; Yastikli, 2007; Zheng, 2000).

CyArk (http://archive.cyark.org), located in Oakland California, is a non-profit organization dedicated to the digital preservation of world heritage sites at risk of destruction. By partnering with industry, governments, and university researchers, CyArk captures and stores digital data on important heritage sites, often in the form of 3D point clouds recorded using TLS. Laser scanners emit a pulse or laser beam of light that strikes the surface of an object, such as an artifact or building. The instrument then measures the lasers “time of flight”, recording the time it takes for the beam to strike a surface and make its return. With two mirrors, the scanner calculates the beams horizontal and vertical angles, giving accurate x, y and z coordinates. This is done millions of times, creating a dense three-dimensional cloud of points in a coordinate system that forms the shape of the objects being scanned (Al-Khedera, et al., 2009; Armesto-González, et al., 2010; Dawson, et al., 2013; Dawson et al., 2009; Entwistle, et al., 2009; Lobb, et al., 2010; Ruther et al., 2009; Tapete, et al., 2013; Van Genechten, et al., 2011; Yastikli, 2007; Zheng, 2000). High-resolution scanners usually have very short ranges of only a few centimeters and operate at .00002 mm accuracy. Mid-resolution scanners have ranges about 5 m or less, provide resolutions of .03 mm, but are sensitive to light levels. Long-range scanners have a range of more than 100 m and use advanced techniques such as echo digitization and online waveform processing to achieve higher resolutions. These scanners can capture objects the size of buildings, and operate under a wide variety of lighting conditions.

Our research group is currently using TLS data to monitor polar heritage sites at risk, and to create 3D computer reconstructions of historic buildings and artifacts. Monitoring involves the regular and repeated scanning of heritage sites over time. The structure and composition of point clouds from different time periods are then compared statistically using a technique called change detection analysis. This allows for the identification of erosion, land subsidence effects on buildings, the movement or removal of artifacts, and other changes that may have occurred at the site. Point clouds can also be used to create meshes for the 3D modeling of objects. In 2010, the authors used a Z+F Imager 5000i laser scanner to record all the cultural features and topography at Fort Conger (Figure 2) (Dawson, et al., 2013). Over a period of twelve days, a total area of 34,500 m² was recorded from 43 scanner locations, resulting in 3D point clouds capturing all the cultural features present at the site (Dawson, et al., 2013). These point clouds are currently being used to monitor the site, as well as create 3D models of various artifacts and structures, including Robert Peary’s hut complex. CyArk currently hosts an interactive digital repository of the Fort Conger TLS data that is publicly accessible (CyArk 2013) (http://archive.cyark.org). This includes an interactive viewer for examining point clouds of various historic buildings and artifacts. Users can also access a gallery containing animations, historic photographs, and documentation of the laser scanning survey. While the heritage archive has been
a useful way of raising public awareness of threats to global heritage sites, it falls short as a vehicle for communicating the more complex messages that define Fort Conger’s significance. Consequently, we have begun to explore how educational technologies such as virtual environments and serious games\(^2\) can be used to effectively communicate information about polar heritage to a broader audience.

**Figure 2.** Photograph of Fort Conger as it appeared in 2010.

## 5 Communicating the Significance of Polar Heritage

The historic and cultural values associated with polar heritage sites are often challenging to define and communicate to the public (Bennet, 1995; Dick, 2008). This is not because values are lacking or that individuals and groups lack opinions on what those values are. Rather the remoteness of polar heritage sites severely limits opportunities for visitor experience. Furthermore, government agencies have tended to narrowly define the significance of polar heritage around the tragedies and achievements of Euro-North American explorers, often at the expense of other heritage values (Dawson et al., 2015). Commemorative integrity is a process aimed at identifying heritage values and objectives for managing heritage sites as cultural landscapes (Bennet, 1995; Dick, 2008). An important component of the commemorative integrity process involves identifying and communicating the reasons why a site was commemorated. Traditionally, many polar heritage sites are memorialized because of their connection to ‘The Heroic Age of Arctic and Antarctic Exploration’. Tying heritage to such nationalistic pursuits as the quest for the poles, and the search for the Northwest Passage, is often used to leverage arctic sovereignty claims made by countries like Canada (Coates, et al., 2010; Hodgetts, 2012). For example, the Historic Sites and Monuments Board of Canada declared the Franklin Expedition ships *HMS Erebus and Terror* as National Historic Sites in 1992, even though the ships would not be discovered until 2014 and 2016, respectively. In deference to these discoveries, former Prime Minister Stephen Harper remarked that this was “...truly a historic moment for Canada. Franklin’s ships are an important part of Canadian history given that his expeditions, which took place nearly 200 years ago, laid the foundations of Canada’s Arctic sovereignty” (Humphries, 2014).

While memorializing the achievements of polar explorers serves an important political purpose, there are other messages of significance that should also be drawn out and communicated to the public at large. Such messages center on the scientific achievements of early polar expeditions and how this paved the way

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\(^2\) A serious game or applied game is a game designed for a primary purpose other than pure entertainment. Serious games have been used in industries like defense, scientific research, emergency management, and education.
for the development of contemporary polar science. They should also focus on the contributions made by Indigenous peoples to polar expeditions, as well as the hardships they often suffered while working alongside their Euro-North American counterparts. Other messages should draw attention to the environmental and cultural impacts that large scale industrial resource extraction activities such as whaling and sealing had on arctic ecosystems and Indigenous peoples. It is therefore imperative that we explore new ways of effectively drawing out and communicating key messages of heritage significance to general audiences.

6 Digitizing Polar Heritage: The “Science and Survival” Project

As mentioned previously, agencies such as Parks Canada rely heavily on visitor experience to communicate why certain heritage sites have been deemed significant. This usually involves physically visiting locations where historic buildings and machinery have been restored to create an impression of what daily life would have been like in the past. Within these heritage settings, visitors often interact with staff members dressed in period costumes who have assumed the personas of historical characters. These kinds of immersive experiences are thought to make visitors more receptive to understanding why the site has been deemed significant. Online virtual heritage environments created using 3D media offer a viable alternative when opportunities to physically visit heritage sites are restricted – as is the case at sites like Fort Conger. These types of educational technologies, which also include “serious games”\(^3\), have proven an effective means of communicating history to non-specialists (Kansa et al., 2011; Levesque, 2014; Levy and Dawson, 2014). Studies show that important issues can be effectively transferred using instructional technologies involving photo-realistic virtual worlds and games (Kee, 2014) (but see Levesque 2014 for an alternate view).

To evaluate this premise, we received funding from the Virtual Museum of Canada to create an online virtual exhibition called “Science and Survival at Fort Conger”\(^4\). The objectives of this project were to utilize the TLS data obtained in 2010, to create an interactive 3D reconstruction of how Fort Conger would have appeared during the British Arctic Expedition (1875-76); Lady Franklin Bay Expedition (1881-84), and Robert Peary’s attempts to reach the North Pole (1899, 1905, 1908) (Bertulli, et al., 2013; Dawson et al., 2013). Reconstructing cultural features was an iterative process that involved moving back and forth between historic documents, photographs, and TLS data (point clouds) to create accurate and realistic models of expedition ships, buildings, observatories and scientific instruments, and items used in daily life (Dawson et al., 2011; Zheng, 2000). While no substitute for visiting the actual site, our intention was to use the immersive experiences generated by the models to effectively transport users to another time and place.

There were several key messages we wanted the virtual exhibit to communicate. The first focused on the idea of Fort Conger as an evolving cultural landscape. The World Heritage Committee defines a cultural landscape as “the cultural properties [that] define the combined works of nature and of man” (Fowler, 2003). At Fort Conger, each successive expedition shaped and changed the landscape of northeastern Ellesmere Island through the addition and subsequent demolition of various structures, the removal of vegetation, and the deposition of refuse. The second message involved the growing importance of ‘situated technologies’ during Fort Conger’s history. Situated technologies privilege the local, context-specific and spatially contingent dimension of their use. At Fort Conger, early expeditions attempted to adapt Victorian era technologies to arctic environments, while later expeditions recognized the value of using Indigenous technologies. As these technologies were locally situated and contextually specific they proved far more effective to their adopters. The third message focused on drawing attention to the scientific achievements of these expeditions in relation to the development of contemporary climate science. Outside of these messages, there was also a desire to create content that would allow visitors to experience what life at Fort Conger would have been like during the British Arctic Expedition, Lady Franklin Bay Expedition, and Robert Peary’s North Pole Expeditions.

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\(^3\) Serious games are simulations of activities, including scientific, industrial, aeronautical, and medical, that serve as educational and training tools.

\(^4\) The Virtual Museum of Canada exhibit for Fort Conger is expected to be completed in the first half of 2016.
6.1 Fort Conger as an Evolving Cultural Landscape

People often perceive heritage sites as static and unchanging reflections of historic events and ways of life from long ago. This view obscures the fact that heritage sites are continuously changing as cultural features and objects are added, altered, and removed during successive occupations. Terrain can also be transformed through digging and removing vegetation, and the disposing of refuse. These forms of cultural agency have continuously transformed the natural landscape of Fort Conger, as different expeditionary groups attempted to realize the objectives of their missions. By way of illustration, the British Naval practice of overwintering aboard ship limited the cultural ‘footprint’ of the British Arctic Expedition at Fort Conger. Thus, the physical remains associated with this expedition are limited primarily to the Nares post-office cairn, a few metal storage tanks, and an instrument pedestal constructed from bricks and mortar. The arrival of the Lady Franklin Bay Expedition, a mere five years later, substantially enlarged this Euro-North American footprint (Bertulli, et al., 2013). A large expedition house, constructed from lumber brought to the site aboard the expedition ship SS Proteus, along with observatories, storage pits, and instrument pedestals, completely transformed the tableland adjacent to Discovery Harbor. The landscape then changed again, following the arrival of Robert Peary who dismantled the Greely station house and used the lumber to construct an interconnected complex of three huts (Dick 2001). The Greenlandic Inughuit who accompanied Peary to Fort Conger further modified the tableland and harbor through the traditional activities they engaged in. Thus, the cultural landscape that emerged during Peary’s time at the site reflects the entanglement of Western practices with Indigenous knowledge and technology (Bertulli, et al., 2013; Dick, 2001).

To convey this idea of an evolving cultural landscape at Fort Conger, an interactive timeline of the site was constructed (Figure 3 & 4). Virtual replicas of the various buildings and cultural features associated with a specific time were superimposed on aerial photographs of the site. By selecting a date, the user obtains a bird’s eye view of how the site would have appeared during that period. Clicking from the year 1881 to 1901 shows the replacement of the Greely station house with Peary’s hut complex. The remains of the station house are clearly visible, emphasizing the demolishing of the structure which Peary felt was entirely unsuited to the Arctic. As the user moves through the years associated with each expedition, ships arrive and depart, buildings appear and disappear, and expedition supplies become diminished. Such changes continuously re-enforce the idea that cultural agency is constantly transforming the site into something that reflects the methods and objectives of the three expeditions.

![Virtual timeline, 1881 (Lady Franklin Bay Expedition).](image-url)
6.2 The Growing Importance of Situated Technologies

Each successive expedition to Fort Conger made greater use of Indigenous technologies and traditional knowledge. The situated and locally embedded character of such technologies as traditional hide clothing, dog traction, and dwelling styles meant that they were far better suited to the High Arctic than Western technologies brought from the south. The greatest illustration of the value of Indigenous knowledge at Fort Conger involves the comparison of the large station house built by the Lady Franklin Bay Expedition with that of the much smaller interconnected hut complex constructed by Robert Peary. This message is communicated to users through photo realistic computer reconstructions illustrating how both dwellings were built and used. Each dwelling was literally built “stick by stick” in the virtual world, using Indigenous and Euro-North American construction methods that were common in frontier settings during the 19th and early 20th centuries.

Using architecture at Fort Conger to communicate the significance of situated technologies required that the replicas of each building type were as historically accurate as possible. Reconstructing the Greely station house benefited greatly from the TLS collected in 2010 to preserve the site, as it provided essential data on the topography, artifacts and building foundation (Dawson, et al., 2013). Likewise, TLS data provided a 3D record of the current state of Robert Peary’s huts, constructed in 1901 by disassembling parts of the station house Greely and his men created two decades earlier (Dawson, et al., 2013). However, Peary’s disassembly of the Greely station house meant that laser scanning data alone was insufficient for creating an accurate 3D reconstruction. Thus, documentary evidence in the form of reports, photographs and drawings was used to fill in missing gaps in the data. Photographs taken by George W. Rice in 1881 were particularly helpful in establishing the proportion of Greely’s station house and confirming the location of major architectural features including windows and doors attached to structures including the lean-tos (Figure 5 & 6). The virtual windows and doors used in the computer reconstruction could be sized from laser scanning data and field measurements. The spacing of the floor, roof and ceiling joists could also be determined by dividing the overall length of the building by the number of each one visible in the photos of Rice. Photographs and reports confirmed that doors, windows, stoves bed frames, chairs and tables were all part of the expedition ship SS Proteus’s cargo.
When building the models, architectural features that were adaptive needed to be clearly distinguishable from those ill-suited for use in the High Arctic. Among the most important of these features were the relative differences in building size that characterized each dwelling. The Greely station house was extremely large as compared with Peary’s hut complex. The overall size of the structure as noted in Greely’s Report of 1888 was approximately 65 by 21 ft. Originally planned to be a structure of 68 ft., lumber which was placed on the deck of the SS Proteus became damaged in transit, requiring the overall structure to be shortened by 3 ft. (Figure 7 & 8) (Greely 1888:335). In addition to its large size, the extent of exposed surfaces such as walls, as well as the use of windows and doors, all placed heavy demands on energy consumption. Heat was provided by several large iron stoves that were distributed throughout the station house. During September 1881, the first complete month of occupancy, the house stoves consumed five tons of coal, which was nearly double what had been estimated (Greely 1886:121). Our research indicates that attempts were made by Greely and his men to increase the energy efficiency of their Western-style dwelling. For example, the exterior was constructed using a double-walled design so that a vapor barrier could be created to reduce excessive condensation (Greely 1888, 1886, 1884). Construction of an attic, double doors, window shutters, and an exterior snow wall were also employed to reduce energy consumption, and are all apparent in the virtual reconstruction of the station house (Greely 1888, 1886, 1884).
Building a structure as large as the Greely station house also required specialized carpentry skills that were often lacking among US Army officers and enlisted men. Construction techniques like balloon framing were used to solve this problem. The term ‘balloon frame’ refers to its lightness of form making it possible to build even a larger structure with one or preferably two framers (Sprague 1981). Planks that could be carried by two men, measuring approximately 10 inches wide, were used throughout the structure for roofing, flooring, exterior sheathing and studs. Unlike heavy timber construction, balloon framing did not require the expertise of highly skilled carpenters (Sprague 1981). Someone with a limited knowledge of carpentry, with only a saw, hammer, and a bag of nails could construct a house using pre-milled lumber. In addition to its simplicity of form, balloon framing does not require any scaffolding, hoists or cranes. It is not uncommon to find in historic photos only a single ladder on the job site of balloon framed structures (Sprague 1981). Computer animations and still images of the virtual Greely station house under construction are used in the exhibit to illustrate the principles of balloon framing, and provide the user with an idea of how this process would have unfolded during the first month of the Lady Franklin Bay Expedition (Figures 7 & 8 and supplementary material)
In contrast, Peary’s huts were far more energy efficient, and much simpler to construct. Unlike Greely’s station house, each hut was partially excavated into the ground to take advantage of heat from the earth. Furthermore, the huts were built with six layers of protection, consisting of tar paper, double wooden walls infilled with silt and gravel, and various types of paper consisting mainly of star charts and asbestos paper left behind in the Greely house (Philips Parmenter et al., 1978a 235-236; Broodhagen et al., 1979). Peary and his men also banked the sides of their buildings with earth, turf, and drifting snow. The fact that the hut complex was small, interconnected via a system of snow tunnels, and shared common entrances meant that they could be efficiently heated with minimal expenditures of fuel. Thus, Peary’s huts embody the use of situated technology at Fort Conger through their pragmatic application of proven Inughuit architectural principles, such as modest dimensions, the excavation of house pits, the use of local materials for construction and insulation, and the use of snow tunnels with cold traps. Our 3D reconstruction depicts Peary’s huts as they would have appeared during the summer because many important architectural details of the model would have been obscured by the presence of snow. Regardless, the reconstruction nicely conveys the architectural differences apparent in the Greely station house and Peary Hut complex, thereby illustrating the growing importance of situated technology at Fort Conger (Figure 9).

Figure 9. Computer reconstruction of Robert Peary’s hut complex. The roofs have been removed to show interior details.

6.3 Scientific Achievements at Fort Conger

As mentioned previously, Fort Conger’s significance as a polar heritage site is partially derived from the numerous scientific achievements of the British Arctic Expedition and the Lady Franklin Bay Expedition. Drawn out of these achievements are messages dealing with the enormous challenges of using 19th century scientific instruments in extreme conditions. Observatories were built to house delicate instruments, including magnetometers, which were used to measure the earth’s magnetic field (Figures 10 & 11). In this particular case, the observatory had to be built without nails so that it did not interfere with the magnetometer measurements. It was located a few steps away from the main building (Greely 1888:105).

The computer reconstruction provided some interesting insights into the role that surveillance may have played in the day to day operations of the expedition. Lieutenant James Booth Lockwood was charged with administrating the scientific work done by Lady Franklin Bay expedition members (Greely, 1886). In many cases, scientific observations needed to be recorded at regular intervals, regardless of weather and other challenges. Lines of sight generated by the computer model revealed that the magnetic observatory, in which a device called a filament magnetometer was used to measure flux in the earth’s magnetic field at scheduled times, was directly visible from the window above Lockwood’s desk (Figure 12). Consequently, the ability to visually monitor the observatory would have provided Lockwood with assurances that the data was being collected per schedule.
Figure 10. Computer reconstruction of a 19th century magnetometer.

Figure 11. Computer reconstruction of an observatory at Fort Conger.

Figure 12. The view from Lt. Lockwood’s window of the observatory, allowing for the monitoring of regular scientific observations.
Of interest to us were the gravimetric surveys conducted at Fort Conger using pendulums. This was due to both the complexities of pendulum operation, and the role that the pendulum taken to Fort Conger ended up playing in the rescue of the surviving members of the Lady Franklin Bay Expedition (Levere, 1993; Robinson, 2013). Scientists during the 19th century believed that if enough pendulums were swung at enough latitudes, then the resulting gravity measurements could be used to calculate the shape of the earth to a greater level of accuracy. This was one of the reasons behind the gravimetric survey work completed at Fort Conger by expedition astronomer Edward Israel (Greely, 1886). The survey used a pendulum provided by the US Coast Survey called the Peirce No. 1, named for its designer Charles S. Peirce. Peirce instructed Israel in its use before the expedition. The pendulum was then packed in a long wooden case, sealed with tin, and carried north on the expedition ship in 1881 (Greely, 1886; Levere, 1993). The Peirce No. 1 pendulum was used to determine the force of gravity (g) at Fort Conger, a determination that would be used to assist in calculating the oblateness (shape) of the earth (Levere, 1993). Similar pendulum observations were to be carried out simultaneously at other International Polar Year stations throughout the Arctic.

During the first winter at Fort Conger, a concrete base was poured to create a stable platform for the pendulum. The platform was then enclosed within a lean-to structure built on the north side of the house (Greely, 1888, 1886). A snow wall was then erected around the structure to help regulate temperature, as well as eliminate drafts that might affect the pendulum’s motion. A door or window was built into the north wall of the house so that measurements could be recorded without having to enter the lean-to, thereby preserving the ambient temperature and humidity of the interior (Greely, 1888). The Peirce No. 1 was taken out of its case and hung from its frame inside the structure. Operation of the Peirce No. 1 was a demanding task. The pendulum was swung for 90 minutes then reversed and swung again for a further 30 minutes, both swings to be within a very specific and narrow range of motion between 0.005 and 0.0025 of the pendulum’s arc radius (Greely, 1886; Levere, 1993). This procedure was repeated many times over six hours each day. Expansion and contraction of the metal pendulum caused by temperature changes would affect the period of oscillations. Consequently, thermometers were set up near the top and bottom of the pendulum without touching it and the temperatures of each could not vary perceptibly from one another during the swinging of the pendulum (Levere, 1993). The absence of sunlight during the height of an arctic winter means that there is little difference between daytime and nighttime temperatures. While this made winter ideal for conducting pendulum observations, it often tested the limits of astronomer Edward Israel. In his book Three Years of Arctic Service”, Greely writes:

The severe cold made the work of the most trying character to our astronomer, Sargent Israel. He made the observations on the 14th, in temperatures varying from -540 F (-47.80 C) to -560 F (-48.80 C). A few days later, being exposed for a long time to a temperature of -480 F (-44.40 C) in the open observatory, he froze superficially one of his feet. Apart from the pendulum experiments, though tedious, and involving exposure and suffering were most fortunately and successfully conducted. (Greely 1886:180).

The flexure of the frame supporting the pendulum was also measured and could not vary more than 0.005 mm. In January 1882, Israel carefully swung the Peirce No. 1 under these exacting constraints for 16 days, after which it was once more placed in its wooden box and sealed with tin (Robinson, 2013).

For the results from Fort Conger to be as useful as possible, the Peirce No. 1 had to be returned to Washington DC to be swung by Peirce and the two sets of measurements compared. It is to the great credit of Lieutenant Greely and his colleagues that, as they began their retreat from Fort Conger in August 1883, they carried with them the pendulum in its case, weighing more than 40 kilograms. As their journey to Cape Sabine became more desperate, Greely was prepared to jettison the pendulum but his men objected, although to lessen the weight, they removed the tin cover. Eventually they left the pendulum in its wooden box, together with a note as to their location, protruding from the top of a rock cairn on Stalknecht Island near their final camp on Cape Sabine (Greely, 1886; Lenzen, 1975; Levere, 1993).

When they were finally rescued from Cape Sabine in June 1884, Edward Israel was not among the survivors, having died 24 days earlier (Greely, 1886). The rescue party had seen the cairn on Stalknecht Island and from its note had been able to find the survivors (Robinson, 2013). The Peirce No. 1 was recovered from the cairn and eventually returned to its designer at the Coast Survey in Washington. Unfortunately, Peirce found that the
mass and length of his No. 1 pendulum had changed significantly since he had prepared it for dispatch to the
Arctic in 1881, and considered that the scientific value of the measurements taken by Israel were questionable.
Understandably, this infuriated Greely. Peirce delayed his report on the expedition’s gravimetric data for over
two years and finally submitted it after the US Army put great pressure on the Coast Survey (Robinson, 2013).

The remarkable story surrounding the Peirce No.1 pendulum made it an important object for computer
reconstruction (Figures 13 & 14). However, very little specific information exists about how the Peirce No.
1 pendulum was operated, or how observations were taken. Archival work indicated that when swung,
periods of oscillation were measured using a set of scales that were observed through a small telescope.
Furthermore, these measurements were likely taken by candle light, as gravimetric surveys were undertaken
during periods of winter darkness. The first challenged involved building the computer model of the
pendulum itself. Experimentation revealed that it had been hung on two knife edges that could be moved
up and down the pendulum. Adjusting the position of the knife edges up along the length of the pendulum
would have been necessary to match the periods of oscillation, which was required to calculate the force
of gravity. The other challenge involved identifying exactly where the pendulum observations would have
occurred. Historic photographs indicate that two lean-to structures were attached to the Lady Franklin Bay
Expedition house, and plans of the house illustrated where the pendulum would have been placed. Our
reconstruction scenario is further supported by TLS data, which shows that the brick and mortar pedestal
used to support the pendulum frame, is located adjacent to the end wall of the building where the officer’s
quarters were located, and where the lean-to would have been erected.

Designing a game for the virtual exhibit that was based on the pendulum experiments conducted at Fort
Conger benefited directly from our experiments with the virtual pendulum reconstruction. The completed
game requires the user to swing the virtual pendulum and record its period of oscillation in both upright
and inverted positions. The user is then asked if the oscillation periods match. If they don’t, then the user
must work through a series of cases in which the knife edges are moved slightly up or down the pendulum
until the oscillation periods match. The game then automatically calculates the force of gravity by means
of a formula used by Edward Israel. Admittedly, the pendulum game is a simplification of what would have
been a very complex and demanding process. It was also an experiment done under extremely challenging
conditions (low light, low temperatures) which are impossible to simulate in a virtual world. Regardless,
the pendulum game provides the user with an idea of how 19th century science was practiced, as well as
what problems scientists were interested in solving. Furthermore, reconstructing the experiment in virtual
reality provided new insights into how gravimetric surveys would have been conducted at Fort Conger, as
well as other IPY stations.
6.4 Experiencing Daily Life at Fort Conger

In addition to communicating specific messages, it was also imperative that the completed models provide users with an immersive experience like what one would find when physically visiting a heritage site where actual buildings and artifacts are encountered. Achieving this required computer models that were highly detailed in their depiction of exterior and interior spaces (Figures 15 & 16). Documents such as Greely’s Report of 1888, provided information on the plan and interior design of the station house, including officers’ (26 x 21 ft.) and enlisted quarters (40x21 ft.), a kitchen (14x8 ft), a bath area and hallways (7 ft. wide). The enlisted quarters would have also served as a dining area with chairs and tables that could be rearranged to suite the daily needs of the occupants. In a corner of the enlisted men’s area, a spaced devoted to scientific observation would have included a chronometer, chronograph, barometer and other scientific instruments (Greely, 1888: 340). Of note, a hand-drawn plan, “Plan of the House of Fort Conger”, found at the Explorer’s Club in New York contained critical information on the interior layout of rooms, the location of doors and windows, and the approximate size and location of the two lean-tos on the north and south faces of the building. Also, noted in this hand drawn plan is the location of furniture including tables, beds, desks and stoves. Of interest were the brick and mortar piers for the pendulum and frame used to determine the gravitational constant for Fort Conger. The hand-drawn plan indicated that the pendulum was housed in one of two lean-to structures attached to each end of the station house. Modelling the interior of the building required the use of TLS data, as well as historic photographs and documents. Objects such as the iron stoves were built using meshes constructed from the point clouds of actual stove parts recorded at Fort Conger during the 2010 laser scanning survey. Other objects such as fire arms, clothing, food containers, and place settings were likewise modelled using historic images and photographs obtained through archival research. Knowledge of the many objects founds in these spaces, including beds, stoves, gun racks, chairs and tables, made it possible to produce a convincing reconstruction of the officer and enlisted men’s area, kitchen and scientific area. Within the virtual exhibit, users are able to move from one area of the dwelling to another by clicking on a series of hot spots (Figure 17). A gallery of panoramic images of the officer’s quarters, science area, kitchen, and enlisted quarters also provide opportunities to experience the station house in 360 degrees.
While the completed model of the Greely station house is highly accurate and extremely realistic, there were data gaps that occasionally required the use of analogies. For example, when modeling interior spaces where no photographic evidence exists, plan views were supplemented by photographs of actual military barracks from the period (Camp Reynolds and Ft. Davis, Texas). Furthermore, while historic photographs
provided detailed information about the contents and layout of the officer’s quarters, the resulting computer reconstructions fail to capture the disarray that characterized Lockwood’s quarters (Figures 18 & 19). Archival sources indicate that Lockwood’s messiness was a source of tension between himself and Greely. Consequently, the overly organized appearance of Lockwood’s bunk and desk in the computer reconstruction could be criticized for betraying the existence of these sorts of social tensions among the men. Like many computer modeling projects, the time required to capture the personality of a space can exceed the projects resources.

Figure 18. Historic photograph of Lt. James Booth Lockwood’s quarters.

Figure 19. The corresponding computer reconstruction of Lockwood’s quarters.
7 Discussion and Conclusions

The Science and Survival Exhibit is an innovative and exciting way of presenting the history and significance of Fort Conger to the public. The project also raises several important issues. While an in-depth examination lies beyond the scope of this paper, a few of these issues are worth mentioning. For example, to what degree are the meanings and values associated with the real Fort Conger transferred to its digital replica? Traditionally, these values have been defined primarily by the achievements and tragedies of 19th century explorers. However, a large part of our virtual exhibit focuses on the digital preservation of Fort Conger; a site where climate change and human activity currently pose considerable threats. Hence, the act of digitizing heritage itself becomes a powerful message conveying that Fort Conger, like sea ice, is fast disappearing from the arctic world. This would seem to suggest that users are likely to derive an entirely different set of meanings and messages from our digital replicas.

A related issue concerns the authenticity of our photorealistic reconstruction of Fort Conger in the eyes and minds of online users. An account by Stephen J. Gould of a visit by a group of visually impaired people to the Smithsonian Air and Space Museum provides an informative analogy in this case (Gould 1990). The story involves the Spirit of St. Louis, the plane used by Charles Lindberg for his famous trans-Atlantic flight. This famous airplane is currently suspended from the ceiling of the Boeing Milestones of Flight Hall. Members of the group were asked if a replica of the plane that they could touch would be of benefit to them. The response was yes, but only if the replica plane was placed directly below the real Spirit of St. Louis - which was of course invisible to them. In this instance the degree of authenticity associated with the replica appears to have been conditioned by its proximity to the actual object. Like the Spirit of St. Louis, Fort Conger remains invisible to most of the public because of its remote location. However, the space-time compression that often occurs when technologies like the internet condense or elide spatial and temporal distances eliminates the vast distances that separate the real Fort Conger from our virtual reconstruction. How might the authenticity of our virtual Fort Conger be perceived if there is no way to gauge its proximity to the actual site?

Another issue warranting future consideration relates to cyberinfrastructure. Virtual exhibits focusing on polar heritage need to be accessible to global audiences – especially those living in remote arctic communities. Unfortunately, creating photorealistic game-like experiences requires access to substantial bandwidth, state of the art graphics cards, high resolution displays, and powerful computer processors. These prerequisites are largely absent in many remote communities, where satellite and dial up internet service is slow, expensive, and largely unreliable. Consequently, virtual exhibits need to be designed and developed with these limitations in mind. Virtual exhibits should also be planned to ensure all users have equal access to information and functionality. The needs that virtual exhibits should address include visual and auditory impairments, mobility issues relating to hand movement, seizures, and cognitive impairments. These are often conditions set down by funding agencies such as the Virtual Museum of Canada, and are contained within web accessibility guidelines set down by the Government of Canada. Every attempt was made to adhere to these web accessibility guidelines for the Science and Survival Project, and this has often meant foregoing the use of technologies such as gaming engines, using descriptive captions extensively, and reducing file sizes to minimize loading times.

In conclusion, the Science and Survival at Fort Conger project represents one of the first attempts to use virtual worlds to draw out and effectively communicate key messages of significance for polar heritage sites where opportunities for first hand visitor experiences are often severely limited. Official messages of significance have tended to focus on valour and courage in the face of adversity, as well as the memorializing of tragic events relating to endeavors of exploration. At Fort Conger, this is highlighted by the tremendous loss of life associated with the Lady Franklin Bay Expedition. Because of this, other key messages have often been overlooked. These include the idea of Fort Conger as an evolving cultural landscape, the growing importance of situated technologies in polar exploration, and the scientific achievements of these expeditions. The construction of a virtual exhibit involving photorealistic 3D models of buildings, scientific instruments, and other objects can be used to effectively convey such messages, as well as create a sense of what it might have been like to have been a part of these expeditions. Visitor experience remains an
essential means by which heritage agencies communicate the history and significance of heritage sites. The reconstruction of actual historic buildings and objects at National Historic Sites, along with the use of period costumes and role playing, have also proven popular with the public. Educational technologies such as virtual exhibits provide an alternate means of presenting reconstructions of the past in situations where physical visitation is severely limited. Polar heritage sites are intrinsically linked to our national identity and history as a circumpolar nation. The fact that many are currently threatened by processes associated with climate change and human-caused destruction mean that costly interventions will be necessary if they are to be preserved. This will require the support of a public who currently remain largely unaware of their existence and significance. Consequently, mobilizing knowledge about polar heritage and its significance using virtual exhibits like “Science and Survival” is one of the ways such support can be gained.

Supplementary Material


References


Lackenbauer, P. W., Manicom, J., Centre for International Governance Innovation, and Canadian Electronic Library (Firm). *Canada’s northern strategy and east Asian interests in the Arctic*.


