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THE USE OF MULTI-RESOLUTION LASER SCANNING/WHITE LIGHT SCANNING TO RECORD THE HISTORIC HUTS OF SCOTT AND SHACKLETON IN ANTARCTICA

RUSSELL GIBB[1], DAN MCCURDY[1]
AND ROBERTA FARRELL[2]
[1]GEOMETRIA LTD, [2]UNIVERSITY OF WAIKATO

Introduction

This paper introduces recent laser scanning/white light scanning and modelling work undertaken on Scott's huts at Hut Point and Cape Evans and Shackleton's hut at Cape Royds, where scan data is being integrated to support multidisciplinary studies and develop interpretative models for broader public consumption. This work is being conducted under the auspices of the Antarctic New Zealand K021 Event. The wooden huts assembled in Antarctica by Scott and Shackleton during the heroic era of Antarctic exploration represent one of the great episodes of human endurance and endeavour. 100 years on, these huts remain in situ in one of the most inhospitable environments on earth. Remarkably, they survive in relatively good condition, a haunting legacy of exploration. By virtue of their remoteness the huts have not been subject to major human impacts since their abandonment about 100 years ago, aside from more recent scientific investigations of deterioration and conservation of the huts and their contents.

The complexity of these sites and contents, coupled with their inaccessibility, makes them well suited to digital recording, modelling and remote interpretation. However, data acquisition in Antarctica is complex and time-consuming and this is problematic in an environment where available operating time is usually at a premium. Using different scanning technologies, recent surveys of the buildings, and their unique contexts, have allowed a truly accurate record of these structures, their contents and immediate environs, to be produced at a variety of scales. Such a record forms an essential component of the planning and implementation of their conservation, scientific analysis and interpretation. Dissemination of this data allows a broad spectrum of project partners with disparate needs to undertake specific analysis or interpretation. These include archaeologists, conservation architects, conservators and microbiologists working under the auspices of Antarctic New Zealand K021 Event, as well as audiences interested in the interpretation of aspects of the cultural heritage and history of these sites.

Background

The early expeditions to Antarctica erected pre-fabricated wooden buildings and brought in large quantities of supplies for the survival of the parties. On Ross Island, three heroic era huts were constructed in the early 20th century. Discovery Hut was erected at Hut Point (77•85ºS, 166•63ºE) in 1902 by the National Antarctic Expedition led by Robert Falcon Scott and served as a shelter, workshop and supply store. The hut and supplies were abandoned at the end of the expedition in 1904. The second of the Ross Island huts, Nimrod Hut, was erected at Cape Royds (77•55ºS, 166•15ºE) in 1907 by Ernest Shackleton during the British Antarctic Expedition and abandoned in 1909. Scott returned to Antarctica in 1910 with the British Antarctic Expedition and erected Terra Nova Hut at Cape Evans (77•63ºS, 166•40ºE), which was abandoned when the survivors of the ill-fated expedition left Antarctica in 1913 (Figure 1). The huts were occupied off and on until 1917, when Shackleton's Ross Sea party were the last to use the huts. During the 1940s the huts were revisited and restoration work began on Discovery Hut in 1957. Discovery Hut's close proximity to McMurdo Station and nearby Scott Base has resulted in it being most affected by human impact, but all the huts have suffered impacts to some degree. Since the 1960s the huts have received increasing numbers of visits from conservators, scientists, staff from the local bases, and in more recent times, tourists from cruise ships.

Wood and other organic material introduced new sources of nutrients to the Antarctic environment. One of the main research goals of K021 has been the investigation of biological and non-biological factors affecting the huts and their associated environs. These studies have focused on the evaluation of biological and non-biological deterioration (Farrell et al. 2004, 2008), the affects of fungi (Blanchette et al. 2010, Duncan et al. 2010), cellulose degradation (Duncan et al. 2008), non-biological affects on the physical and chemical structure of wood (Held et al. 2002), wood defibration (Blanchette et al. 2002), wood rot (Blanchette et al. 2004) and environmental factors that influence microbial growth in the huts (Held et al. 2005).

Studies of deterioration of the huts have more recently included examining the effects of conservation work being undertaken by the New Zealand Antarctic Heritage Trust (Farrell et al. 2008). Conservation and mitigation work that began in 2005 has brought about changes to localised microenvironments in and around the huts. The conservation work has included removing ice from in and around the huts, replacing exterior and interior wood and the conservation of artefacts and structural elements. The conservation work is guided by conservation plans prepared for the huts and significant structures located within their immediate environs. Detailed photographic archives record the configuration and observable fabric of each structure prior to the start of the conservation work.

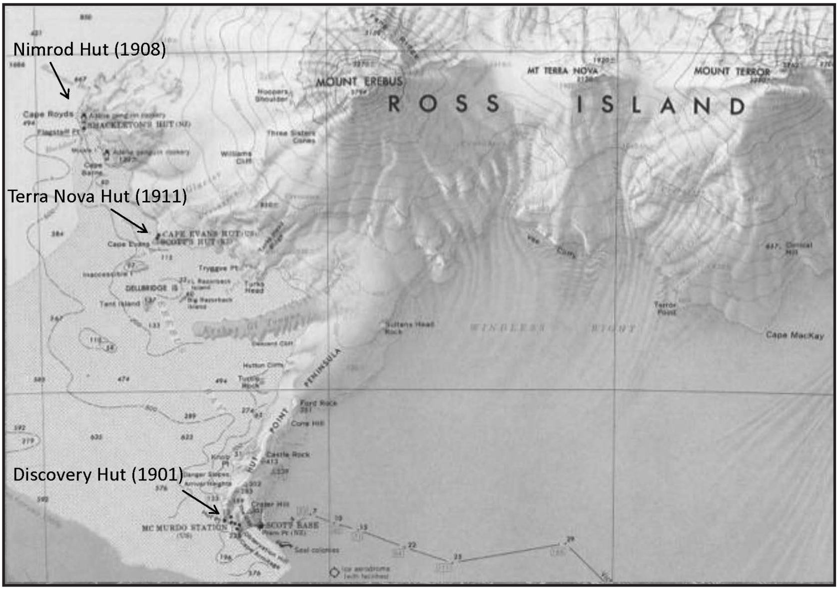

Figure 1. Location of Ross Island Heroic Era Huts, Antarctica.

Multi-resolution digital recording

Previous scientific data capture has generally focused on studies at the micron level, whereas the data captured for the conservation plans has been recorded at a much larger scale and as a result of the recording methodology, is recorded at a lower resolution. The two datasets, however, are not independent of each other. The effects of biological and non-biological deterioration can and should be measured across a range of scales, while the huts and their interiors can be recorded in three dimensions at a higher resolution and the datasets combined to provide a basis for the analysis, measurement and interpretation of the science and conservation being conducted. To achieve this, a multi-resolution recording approach using laser and structured-light scanners has been employed. There are several key objectives in employing this approach. The completion of high-definition surveys of these sites will establish an accurate archive of Discovery, Nimrod and Terra Nova huts for future heritage management and record not just the huts, but also their important environmental and topographic contexts.

By producing high-resolution three-dimensional digital models over which we can apply and model data taken from the various scientific analyses, specifically the monitoring of non-biological versus biological deterioration, we can analyse and model the effects, relationships and results of the numerous causes of change. The data can be used to elucidate the impact of conservation measures on non-biological and biological deterioration in the huts and artefacts, and provide high-resolution baseline as-built surveys to monitor the effects of the current and future conservation work on the historic huts. Detailed three-dimensional data can be used to create a digital inventory to track artefacts and record attribute metadata. Furthermore, by developing high-resolution records of these structures we can use this data to develop accurate three-dimensional virtual models for interpretation. The inaccessibility of these sites makes remote interpretation a valuable tool.

Equipment

One of the primary goals of this field season was to establish the suitability of scanning equipment in the Antarctic environment, not only with respect to the ability of the equipment to operate at extreme temperature ranges, but also the user operability of the equipment. Firstly, not all scanners will operate below 0oC. Time-of-flight scanners in particular struggle due to the inability of the laser pump to operate in below zero temperatures. Battery life is significantly reduced in cold temperatures while recharge times are extended, reducing surveying efficiency in the field. Wind also presents problems as scanners generally require a stable platform, at least for the duration of each actual scan and wind-blown sands and fine volcanic gravels are not good companions to specialised digital equipment containing extremely sensitive optics. Snow and ice build-up on structures limits target visibility resulting in interrupted returns and obscured surfaces. All laser scanners also have to balance distance and accuracy, whereby the greater the distance, the lower the accuracy and precision due to increased laser spot size. Structured light scanners also require a stable platform and are susceptible to interference from ambient light, which can be a problem in Antarctica with 24-hour daylight and a high albedo (reflective) landscape. They are also sensitive to fluctuations in temperature, requiring recalibration if the ambient air temperature varies by more than a few degrees.

Two scanning instruments were selected for the surveys: a Leica 6100 phase scanner for recording exteriors, interiors and topography, and a Breuckmann3D-HE structured light scanner for detailed high-resolution recording (Figure 2). Although both instruments are technically scanners, they operate in fundamentally different ways. Phase-based laser scanners record point clouds based on the shift in phase from the emitted and returned continuous light signal while structured light scanners measure the distortion of a known projected pattern by a surface. The recording resolution for the Leica 6100 is ≤3 mm at 90% albedo up to 50 m with the ability to collect 508,000 point of three dimensional point data per second (Leica 2010). The Breuckmann3D-HE can record field of views up to 1200 mm with resolutions down to hundreds of microns, depending on the lenses used.

Figure 2. Exterior scanning using the Leica 6100 (left) and the Breuckmann3D-HE (right) at Terra Nova Hut.

Nikon D300 and D80 digital SLR cameras and assorted lenses were used for photographic recording and texture mapping. Location coordinates were recorded using a Leica RTK GPS.

Antarctic logistics also played a role in equipment choice. As the huts were reached by helicopter, weight limits needed to be factored into equipment selection, as all camping supplies, survival and science equipment were flown in. The K021 field party comprised six people, transported in one helicopter, with our equipment limited to 640 kg carried in a sling under a second helicopter.

Surveys

Recording a complete surface coverage is a process dependent on overlapping scans where parts of a surface obscured in one scan can be recorded from another and the scan point clouds merged together to fill occlusions from the previous scans. This is an iterative process that sometimes involves hundreds of scans registered together to achieve optimum coverage. Complex structures like the huts, with their confined interiors full of artefacts (Figure 3) and their exteriors littered with detritus, present numerous challenges for recording, not in the least the requirement for large numbers of scans to survey the complex spaces in their entirety. A direct consequence of this is more time in the field and the resultant requirements for extra fuel for generators and camping supplies.

Figure 3. Laboratory table, Terra Nova Hut.

For the interior of the huts, a highest/lowest set-up was employed at each set-up station to achieve the best coverage possible within the limited timeframes. The highest tripod setting (approximately 2 m above floor level) provided the best coverage without utilising platforms or scaffolds that could not be brought on the transport. Setting the scanner on the floor permitted better data acquisition under low elements like bunks, shelves and tables. Exterior scans were usually recorded at variable heights dependent on the location and target. Around the main structures, the location of each set-up was usually dependent on the optimum expanse of surface being recorded. Although the huts themselves were seen as the primary survey target, time was also allotted to record the areas around the huts where large numbers of artefacts lie in situ, and many smaller structures such as meteorological stations and instrument housings still brave the elements (Figure 4). The topography surrounding each hut in part governs the affect of the local environmental conditions and how each hut in turn is affected, thus topography and locality is a significant factor in the degradation of the huts. Away from the huts the scanner was traversed over the landscape to provide the best coverage. Unfortunately phase scanners do not have a great range – the Leica 6100's range extends from 50-100 m depending on the conditions and required resolution – so multiple set-ups are required when undertaking topographic surveys over expansive areas.

Figure 4. Scanning the topography and abandoned stores around Terra Nova Hut.

Results

Surveys were undertaken from January 16-28 2011, starting with Discovery Hut before moving on to Terra Nova and Nimrod. Further work was undertaken at Discovery on return to Scott Base from the field. Exterior and interior reference scans of Discovery were collected, along with a supporting photographic archive of the exterior fabric. Over a period of two days, the exterior of Discovery was recorded with 32 exterior scans at the maximum resolution achievable (1 mm at 25 m). A complete coverage of the exterior was obtained and alignment scans were made of the main access way to provide a traversal link for future surveys of the interior. Limited topography was captured at the site during the building scans. Less emphasis was placed on the topography here as this area has been modified by McMurdo Station operations. During the return visit high-resolution scans were taken of exterior timbers to record ablated wood surfaces (Figure 5).

Figure 5. Section of ablated surface from a veranda post, main entrance of Discovery Hut.

Scanning at Terra Nova was restricted to the recording of all exterior surfaces and associated curtilage and the localised topography due to the presence of Antarctic Heritage Trust conservators inside the hut. Sixty scans were made to record the exterior and a large area surrounding Terra Nova (Figure 6). High-resolution scanning of several artefacts was also tested, using the structured light scanner. This was undertaken to test the efficiency and results of the scanning and registration process in a cold, dark environment. Two metal food cans (one of which had been conserved, and one of which had not; Figure 7), a complex scientific instrument (Figure 8), and a metal artefact were selected for scanning. The cans were selected as a control study to measure future conservation and the others were selected to test the ability of the structured light scanner to record surfaces with different form, detail and reflectivity values within a cold environment.

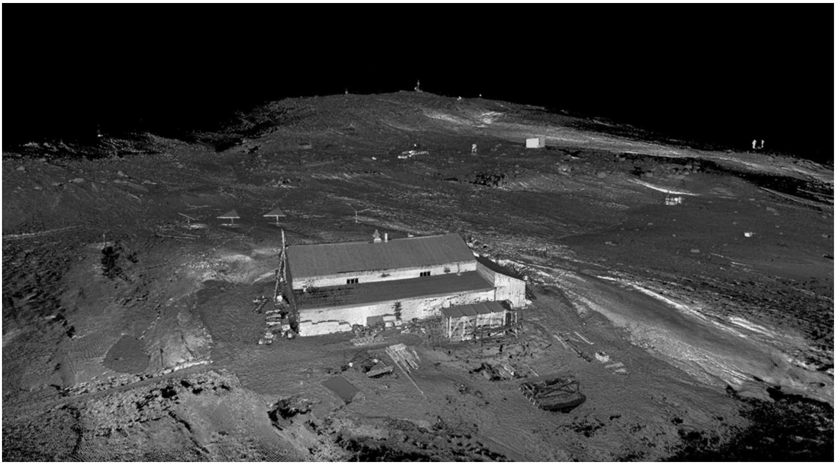

Figure 6. Terra Nova hut and local environs consisting of sixty point clouds registered together.

Figure 7. Raw scan data consisting of approximately 10 million mesh triangles recorded with the Breuckmann3D-HE.

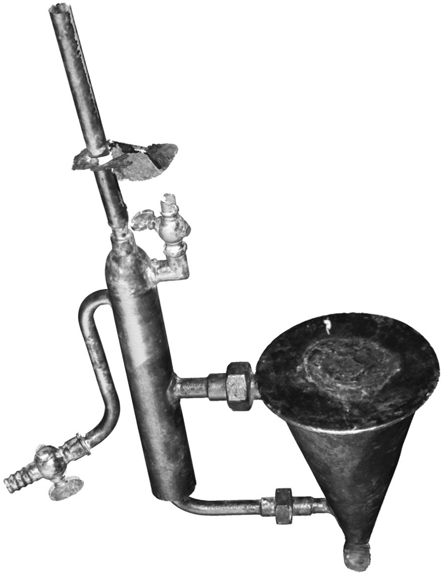

Figure 8. Scientific instrument scanned with the Breuckmann3D-HE.

At Nimrod Hut, detailed recording of the exterior, interior and topography was carried out, along with high-resolution recording of weathered surfaces, areas of defibration and areas of fungal growth. An almost full coverage of Nimrod was surveyed with 42 interior scans (Figure 9) and 28 exterior scans (Figure 10). Within the interior space there are a small number of occlusions, mainly resulting from materials stored on shelves. High-resolution scans of sections of internal timbers exhibiting signs of defibration and Shackleton's stove have been recorded. A series of high-resolution test scans of a largely intact wall of original stores has also been recorded.

At all the sites a detailed photographic record of the site, structures and fabric was made.

Figure 9. Point clouds showing a section of the interior of Nimrod Hut

Figure 10. Exterior of Nimrod Hut with abandoned stores and kennels.

Discussion

Surveys undertaken during the January field season were designed to collect as much baseline as-built data about the huts as possible within a limited timeframe, and record evidence of the various processes of wood deterioration. The process of data collection utilising laser and structured light scanners was untested so the results were a proof-of-concept that validated the research methodology. Baseline data that has been established during the first survey season will be built on over successive surveys. This is particularly relevant for areas of biological and non-biological deterioration such as measurements of weathered erosion affecting the huts. Repeat annual surveys will be used to assess types and rates of deterioration and deformation affecting the structures, and to model the effects of conservation works on the original fabric. More importantly, the data from the two different types of scanner has been integrated to create a multi-resolution scan/surface model. Some data collected previously, such as detailed photography by project partners, will be retrofitted to surface models generated from the scan data.

Over three days at Nimrod Hut using one scanner with a two-person crew it was possible to record an almost perfect coverage of the site and all the structures. Due to the dense assemblages of artefacts it will never be possible to get a complete 100% coverage of the interiors of these complex structures. However, it is still possible to obtain a highly detailed, precise and accurate representative record that far exceeds the detail and accuracy previously collected at any of the sites. Any gaps evident in the data can be filled during surface modelling if necessary.

Although the utility of the scanners in this harsh polar environment has been proven, some issues were encountered when undertaking the surveys. Below -10oC laptops have difficulty charging, rebooting or sometimes waking from sleep mode, and the transfer of large volumes of data from scanner to laptop can be slow. Most consumer-grade hard disks are only rated down to 5oC so laptops and scanners had to be kept warm during any disk activity. Battery life and charging times are severely impeded below 0oC, requiring excessive use of generators. Constant and strong ambient light from the snow-covered terrain and 24 hour daylight, coupled with light-coloured and bleached timber surfaces on hut exteriors can make scanning with a structured light scanner temperamental as the ambient light needs to be reduced as much as possible for the projected light pattern to be recognised by the sensors.

A second survey season is planned for January 2012 where we will endeavour to finish the interior scans on all three huts and undertake more scanning and modelling of ablated surfaces and soft rot areas. A new site at Cape Crozier will be visited and a hut and stone igloo remnants recorded. Future work will involve establishing a digital 3D inventory for the huts and artefacts and creating 3D models for education and tourism purposes.

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