3D Prints and Modern Documentation as an Adjunct to Conservation Techniques

Historic engineering, militaria, and industrial heritage are in general mass produced utilities. In case of a restoration campaign of such heritage, they are often treated in a way that can be best described as maintenance rather than conservation of historical data and material. And often historical technical data on this type of object does not exist or is very hard to find, making physical objects one of the few remaining sources.

In this case study the conservation treatment of a Second World War German EM 4M R40 rangefinder is described. For documentation and museology purposes the object was measured by hand and 3D drawn in Inventor. These digital models were printed on scale 1/10 in ABS using SLS and painted by hand to clarify the archaeological remains of the rangefinder to the museum visitor.

Introduction

The EM 4M R40 rangefinder in this project has an interesting history and was therefore worth studying. After its use by German military, it was shipped to Finland. Finland was one of the German allies during WWII but was considerably poorer at that time. It was common that obsolete technical equipment of the German army would be sold to their allied countries to upgrade their arms and help them defend the axis forces.

After its service in the post war Finnish army, the rangefinder was sold a few times, ending up back in Germany at a dealer who specializes in World War II military equipment. Subsequently it was purchased by the Raversyde Museum in 1995 and placed on top of an observation bunker at the 'Atlantikwall' in Ostend, Belgium at the same spot where it was during the Second World War.

It was on display outdoors for nearly 20 years. Due to the harsh weather conditions and salty air, the object was severely damaged and corroded. With the help of the European Regional Development funds (World War II Heritage funds), two pieces were studied, conserved, and restored: a searchlight and the rangefinder.

The EM 4M R40 Rangefinder

Rangefinders are optical instruments and were used to determine the distance of enemy targets. The German rangefinders ranged from smaller models for individual use in the field to very big stationary models, measuring a few meters in length and operated by up to 12 people [1].

Rangefinders were crucial in warfare during the world wars and should be considered very expensive 'high tech' at the time of use. They are examples of optical instruments of the highest quality ever made. Optical localization systems like the rangefinders became obsolete after the invention of the radar and disappeared.

The EM 4M R40 is 4 meters wide and was one of the bigger models. It is a long tube-like device that would be mounted on a tripod when in use. The EM 4M R40 was used in combination with a heavy FLAK battery (for example a 8,8cm) for air defence. This rangefinder was able to locate targets from 85m to 1000m in distance [2].

This specific type was made in 1940 in the Carl Zeiss optical instruments factory in Jena, Germany. During the Second World War, more than 80% of the factory production was war material for the German army [3]. Big rangefinders like the EM 4M R40 were in use on land, trains, and ships and were widespread in the Atlantikwall complex on the Atlantic coast of Europe

The EM 4M R40 of this case study before restoration in its setting on a bunker at the Raversyde Museum in Ostend, Belgium. The rangefinder is positioned on a tripod, in the front of the picture is the transport chest.

A historic photograph of a EM 4M R40 rangefinder in use by German Soldiers in Lapland (Bundesarchiv bild 101I-110-1699-21 foto Fasshauer 1943/1944) .

Restoration and Conservation of Large Technical Objects

The care of large technical objects like military and industrial heritage is in many cases performed by people who know them, have worked with them, and have an intrinsic deep respect for the object, but are not familiar with contemporary conservation ethics and the representative charters. For example, retired military volunteers often care for old military aircrafts.

Valuable technical objects are commonly cared for in a different way than fine or decorative art or other historical

objects. Very often, such an object needs to function in order to be relevant. In many cases, these types of objects are restored to earlier stages of their life, mostly to when they were in service.

In practice, this leads to excessive restoration, at the expense of information and the character of the object. A famous example of this approach is the case of the only remaining German A7V Sturmpanzerwagen from the First World War. After salvaging by Australian troops it was covered with graffiti by the soldiers and taken to Australia. After years of outdoor exhibition it was restored by sandblasting and repainting it in its 'original' color, destroying very valuable historic information [4].

In modern conservation methodology, the aim of the conservation process is to keep the object in a stable state with respect to its the history. Typically, museums do not wish to return pieces to 'in use' condition. This also seems to reflect the wish of the public, who increasingly care more about the history of the objects [5].

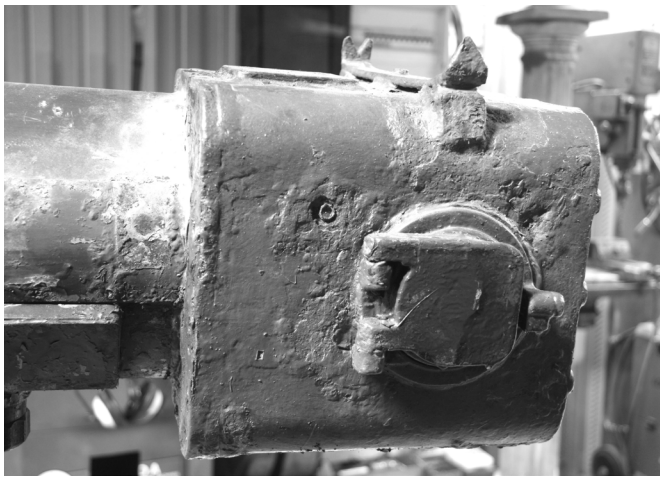
Modern imaging and archiving systems allow new ways to preserve valuable information, allowing better technical and historical understanding of objects.

Study and Conservation of the Rangefinder

State before treatment

The initial purpose of the conservation was to research and repaint the rangefinder so that it could be set up again on top of the observation bunker at the seawall. Due to unexpected findings and increased insight, a completely different approach was developed during examination and treatment.

In November of 2013, the EM 4M R40 rangefinder was transported from Raversyde Museum in Ostend to the workshop in Hoboken near Antwerp. (about 100 Km distance). When carefully examined in the workshop, the object appeared to be in worse condition than was initially observed; there was corrosion present on the metal of the entire object, on the aluminium as well as on the steel parts.



Detail of the left end of the rangefinder with closed lens cap before treatment. Notice the irregular surface due to corrosion under the paint system.

A major part of the corrosion was present underneath the paint layers. At some points, the corrosion was in such an advanced stage that it created holes in the steel. Some parts of the tripod were so severely corroded that they would not have held the heavy weight of the rangefinder and would be bent or broken by manoeuvring.

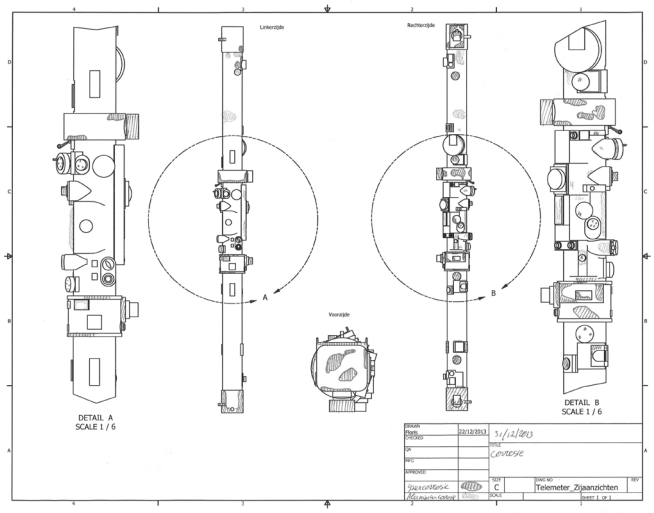
Documentation

When looking for an easy and useful method for recording the different forms and positions of the damage, and as no technical information or drawings could be found, we decided on creating a 3-dimensional digital reconstruction of the object. Detailed and scaled drawings of the entire rangefinder and its tripod were made using Autodesk Inventor 2014 software.

For this purpose the entire object was measured by hand with conventional techniques. The 3D digital models were plotted to technical drawings that were printed on paper. These printed drawings were used in the workshop to quickly record damage, places were different conservation methods were tested, and places where samples of the corrosion and layers of paint were taken.

Because the recording process was on-going during the conservation treatment, markings were done by hand with coloured pencils on the printed version that was later scanned for further editing.

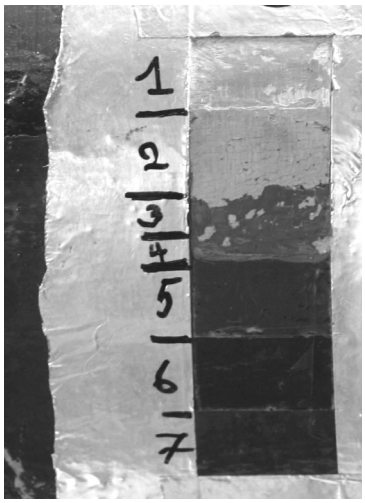
This method of documentation proved to be much more efficient than other techniques, such as using photographs and Photoshop techniques to mark such positions.



The digital model as a technical drawing used in the workshop to document conservation problems. Red zones are corroded iron, green zones are corroded aluminium.

Paint Layer Research

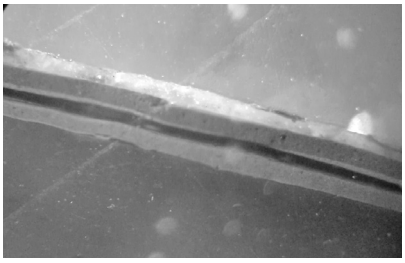
The paint was examined by stratigraphic examination of the layers cross referenced with microscopic samples of paint layers. The stratigraphic research was conducted by removal of sequential paint layers.



One of the paint layer stratigraphies on the rangefinder. Layer one is the primer paint, layer two is the original finishing. Three and four is the Finnish paint system. Layers five to seven were done by the Raversyde Museum.

(The *Newsletter* apologises that we cannot present this in color. Editor)

The microscopy research was conducted by mounting and polishing samples in clear epoxy resin. These samples were polished using Micromesh sandpaper then examined using a Reichert metallographic microscope.



A 200X magnification of an imbedded sample. Sequential paint layers and even pieces of rust can be distinguished. The beige layer at the bottom would be the original colour.
On top of that we find in this case only grey overpainting.
This sample was taken from an area that was either stripped of its Finnish green overpainting or where that layer was damaged.

The analysis was done on multiple areas of the object, the tripod, and transport chest. By studying the layers of paint, we hoped to get insight into the degradation patterns and the different colour schemes over time, in order to fulfill the museum's initial goal of the project, which was to repaint the rangefinder.

Interpretation of Paint Layer Research

Study of the paint analysis, however, yielded interested and complicated results.

The chest in which the pieces were stored and transported was probably made directly for the Finish army, as the only colour on the chest was the typical Finish green colour, which was applied directly onto a metal coating (probably containing tin).

The rangefinder itself had a typical 'Dunkelgelb nach muster' color (a dull mustard), as seen on similar rangefinders and other German equipment.

However, study of the different colors and sequential layering of colors on the parts of the tripod yielded a different story. It became apparant that the tripod was a hybrid, constructed out of different donor pieces with entirely different histories.

Revision of Proposal

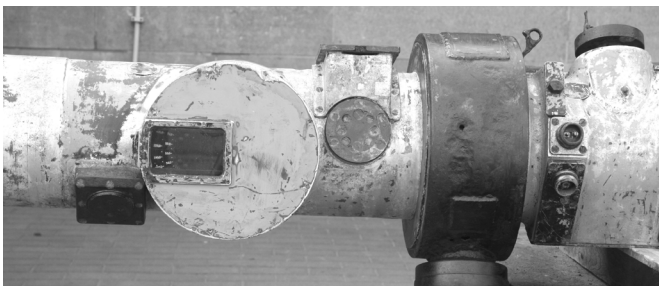
These findings challenged the initial aim, which was to repaint the rangefinder in its "original," or at least an earlier, color, as when in use by the German army. However, this would not respect the history of the overall object in any way, as it now exists. Although this is a fairly common phenomenon with historical military equipment, we did not want to ignore or lose the interesting history of the piece in the choice for its presentation.

These insights, together with the severe corrosion conditions were reported to the museum and an alternative treatment was proposed. Instead of removing all of the old paint and corrosion, it was suggested that as much material as possible would be kept and the object would be conserved as an archaeological finding. In practice this would mean removing or stabilising corrosion and consolidating loose pieces of paint. The museum agreed with this solution.

Conservation Treatment

All of the aluminium corrosion was removed using abrasive methods, together with most of the iron corrosion. Leftover corrosion of the steel was stabilized using OWATROL oil. Paint was consolidated using Regalrez 1094 in a slow evaporating hydrocarbon solvent, with addition of Tinuvin 292 UV-absorber. Afterwards, the entire rangefinder and tripod were varnished with the same recipe.

The result of these actions yielded a rangefinder with a mixture of the different colours running in no logical way up and down the surface of the object. Some parts were corroded so badly no paint could be kept. Some stakeholders even thought this appearance was a kind of special camouflage colour. The appearance of the rangefinder was so badly disturbed that it could not be shown to the public without significant background information.



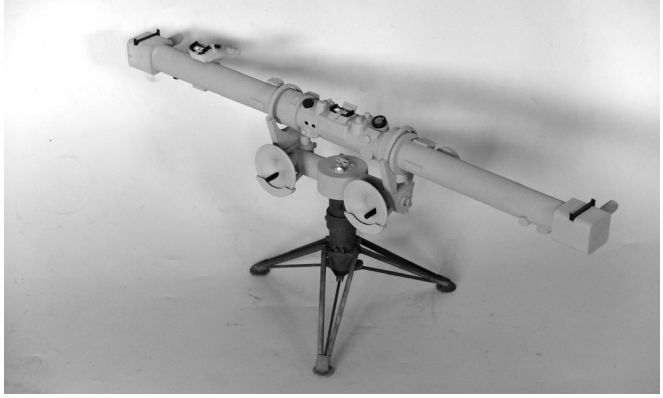
Detail of the rangefinder after removal of loose paint and stabilisation of corrosion. Note the colour differentiation of bare aluminium, stabilized steel (brown), aluminium primer (azure), steel primer (red), original German paint (yellow), overpainting by Raversyde museum (grey-blue).

Modern imaging was the solution. The Inventor drawings were made with such detail and precision that they could be used to make scaled and coloured 3D prints to be presented near the rangefinder and show the visitor where the different colours on the surface were coming from.

The Implementation of 3D Printed Models

Eventually, three different models were made using Selective Laser Sintering in ABS. One was coloured in the red and azure colours of the primer layers that were found on the steel (red primer) and aluminium (azure primer). The second model was coloured in the typical Finnish army colour (dark green), and the third was painted in the original German colours of the object, being a grey 'Feltgrau' for the tripod, and a 'Dunkelgelb nach muster' for the rangefinder.

They will be on display alongside the conserved version and will help the general public to interpret the findings on the original large version.



Conserving the Paint Versus Stripping and Repainting

The value of the information of historic paint has been described before and should not be neglected [6]. The fact is that for these military historical objects, contemporary sources were often destroyed or very hard to find, as engineering data was considered war bounty of great value. This makes the object itself the most important, and sometimes the only, source on related technical data.

During the conservation process a number of interesting things were discovered that would have been eliminated if the initial treatment (sandblasting and repainting) was executed. Among them were the differentiation between electrochemically and physically applied primers on different aluminium parts, machining marks, and even etched-in-the-surface production numbers. These details are not only an important part of the physical structure but also contain information about confidential production processes for the Wehrmacht.

Conclusion

Innovative imaging techniques can be an adjunct to the visualisation and material research of heritage.

The project described in this case study was an object that has a fragmented history, which is very common for technical/ engineering heritage. During restoration, it became clear that the rangefinder and its accessory parts were most probably mixed with other similar models of equipment during their years of service and their years at collectors. The result was a collection of parts that formed a 'complete' rangefinder in its assembled state.

Modern imaging and documentation techniques were used and offered a unique adjunct to conservation techniques; they allowed the object to be conserved in an as-is state and still be understandable for the audience. This meant that the original information like paint layers, fabrication marks, serial numbers, fragile parts, etc., have been kept and secured for the future. At the same time, the visitors to the museum now get a clear idea of the different appearances of the rangefinder now on display.

Acknowledgment

Thanks to Floris Remmen and Silas Hospied for the help with the original drawing, Erik Indekeu for the optimisation of the drawing and printing of the models, Peter De Laet for his kind help during the research. We also would like to thank Kathleen Ribbens and Elke Otten for their enthusiast engagement.

References

[1] W. Müller, 'Die geschütze, ortungs- und Feuerleigerate der schweren Flak', Dörfler zeitgeschichte, Nebel Verlag, Eggolsheim,1988
[2] Dr. H. T. Seeger, Militärische Ferngläser und Fernrohre in Heer, Luftwaffe und Marine, Hamburg, 2010
[3] Worldpresssite bunkeroptiks http://germanmilitaryoptics.wordpress.com/, cited 12/12/2013
[4] http://preservedtanks.com/Types.aspx?TypeCategoryId=10&Select=1, cited 22112014
[5] M.C Robert, Restoring Museum Aircraft, Schiffer Ltd, Atglen, 1997
[6] J. Kemister, BigStuff: Care of Large Technology Objects, Original paint as evidence, editor: Alison Wain, Australian War Memorial, Canberra, Australia, 2004