The Würzburg Riese Radar at the Atlantikwall Museum of Raversyde, Ostend, Belgium – a restoration case study

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Keywords

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This paper presents an overview of the restoration of the biggest collection item of the Atlantikwall Museum of Raversyde in Ostend, Belgium performed in the year of 2014. The Atlantikwall museum Raversyde is situated in a unique location near the seaside and houses a large open-air collection of a part of the German defence line of the Second World War.

The Würzburg Riese radar

The German Würzburg Riese radar of Raversyde is a unique piece of Second World War history since it is the only remnant mobile Würzburg Riese FuSE 65E radar mounted on a railway wagon. The radar described in this paper was captured on the Germans during the Second World War. As was the case in many other countries afterwards this version was reused and converted to a radio telescope for astronomical observation of the sun's radio transmissions by the "Observatoire Royal de Belgique". For this use adaptations and additions were made on the radar during the years afterwards.

The Second World War led to an enormous evolution in the area of military radar development. The Würzburg Riese radar ('*Riese*' German, stands for 'Giant') can be considered as one of the best radars of the Second World War. It was designed to follow one target (e.g. aircraft) over a long distance. Telefunken produced approximately 1500 pieces. The parabolic antenna of the radar was built by Luftschiftbau Zeppelin und Weserhutte (1945, p. 66).

During war, the radar was used by the *Luftwaffe* and *Kriegsmarine* where together with other radars, they formed a support for the FlaK ('*Flieger Abwehr Kanone*') or anti-aircraft artillery. Along the Atlantic wall, including the Belgian Coastline different radar systems were positioned to try to intercept the Allied bombers. Together they formed the German aircraft warning line ('*Anti-Airkraft*').

Technical specifications of the radar

The radar has an operation frequency range of 565 MHz and a detection range up to 70 kilometres. The accuracy is about 25 meters in range and the radar is able to rotate 360° but doesn't turn around continuously. The '*Riese*' version with a diameter of 7,5 meter was introduced in 1941 (Bauer 1999, p. 24 & 32). The parabolic antenna, thanks to its azimuthal properties, is able to follow a moving target. The tracking down itself, is performed by another radar, for example a Freya radar. After detection by the Freya radar , the Würzburg

Riese radar takes over and transmits all acquired data of the tracked object through an intermediate analogue computer device (*Kommandogerät*) to an anti-aircraft artillery unit.

So the antenna is designed to follow one target over a long distance (1945, p. 66).

The advantage of this mobile version was its versatility, it could be put into action on different places wherever a railway line was available and activated in a short amount of time.

The A manual provided text and pictures of how to reassemble the radar with a crew of 3 officers and 20 soldiers. In just 3 to 5 hours the installation was done. All parts were transportable on just four railway carrier wagons. For the purpose of reallocating the radar, the parabolic antenna dish was dividable into three pieces. The composition of the carrier wagons was as following: on wagon 1: the 2 outer parts of the antenna, wagon 2: the central part of the antenna, wagon 3: the spindle and bar and arms (this wagon is present at Raversyde), and finally wagon 4: the operator-cabin (1944, p.7) which housed a crew of 6 (Bauer 1999, p.24) together with the transmitter and the reading device.

History of the radar acquired by the Atlantikwall Museum

During the Second World War this particular radar mounted on a railway wagon was captured from the Germans by the Belgian Army. For the rest of the war it was hidden in a tunnel nearby the station of Etterbeek, Brussels.

Post-war, similar to many other countries, it was reused as a radio telescope for solar research by the "Observatoire Royal de Belgique" (ORB). At the end of the War more than 600 Würzburg Riese radars were left abandoned (Orchiston 2007, p. 221).

In 1951 the Ministry of National Defence gave the radar in loan to the Royal Observatory of Belgium that installed the radar in Groenendael, Belgium. It was adjusted by the radio astonomer M.R.Coutrez (Gonze 2010) to become a radio telescope to perform research on sun and space. In 1954 the ORB acquired the radar in full ownership and brought it by railway to Rochefort, were it left for the radio astronomy centre of Humain, Marche-en-Famenne, Belgium. There it became part of the Royal Observatory.

In 2006 after 50 years of service and attacked with severe corrosion it is taken out of service to find a new home in 2009 at the museum of Raversyde.

Conservation Issues to take into consideration- decision making process

Location

The radar came to Raversyde in an already severe corroded state. Corrosion progressed during the years outside in attendance for the professional treatment. The museum is situated in an extreme salt-saturated and harsh maritime climate near the seaside. The exposition of metal objects outdoors in Raversyde will always remain problematic. Therefore the treatment had to anticipate towards this. Due to the size of the radar, exposition inside was no valid option at the current location.

Since the subject of the museum is the Atlantic wall, the choice was obvious to return the object into the state of the radar during the Second World War. Additionally, the project should take into consideration that at the location site, historically there never was a radar situated (see further).

Constraints in time and budget

Due to the running time of the funding, the treatment of the radar had to be completed by September 2014. So there were only 5 months' time to execute the complete treatment and to find a suitable firm with qualified restorers with the required abilities, capable of executing the treatment in that limited timeframe. Additionally the treatment had a limited budget to be respected. Because of above mentioned constraints, it was opted not to restore the radar to working order, but perform the restoration in such a way that it will always be possible to put it back into operating mode. The choice seems justified since there do still exist other working radars.

Balancing choices in the restoration process

Some parts, like the cabin, were in such a bad state that they would partly have to be replaced, and a compromise between conservation and reconstruction had to be established. Although the value of its interior, completely removing was justified cause this was the valid option to treat the exterior of the cabin.

Because of the dimensions, the weight (25 ton) of the construction and the windy environment safety was a priority within the decision making process of the entire project.

The radar as a large technology item represents a top example of the warfare technological achievement of the Germans. Nevertheless, adjustments were executed in its post-war function as a radio telescope. This forms an important part of the complete history of the object.

Value

To establish an appropriate conservation-restoration treatment, a broad registry of the different values and significance of this mobile object was made beforehand.

Originality – a unique piece

The radar is a unique part of our movable heritage. As far as we know the FuSE 65 E model is the only remnant railway version of a Würzburg Riese radar. In other museums, in astronomical centres and sometimes even on site, Würzburg Riese radars mounted on their base or on other more recent constructions are still to visit (Lippmann 2013). Some radars nowadays used for radio astronomical purposes, as the one of Marcoussis that was later relocated to Bordeaux, started in fact life as a mobile Würzburg Riese. So much adaptations were made that all mobile context was removed (Orchiston 2007, p.223).

Out of this follows that the image of the Raversyde radar is of major importance.

It's the only surviving giant radar in Belgium where there were quite a few active radar stations during the war with over thirty Würzburg Riese radar (Lippmann 2013).

Historic and scientific significance

The radar has a rich history that is representative for a lot of the still remaining Würzburg Riese radars. In this case not too many adaptations or contributions to the representation of the radar during its years in the war were made. Thanks to its radio astronomical context its history is quite well documented. The radar in its current state represents the 2 phases in its life, it had 2 scientific lives: one during the War and a second one in service of the Royal Observatory. It is an illustration of how well advanced it was on a level of its technology that it remained in active service for over half a century before it got its museum destination.

Technological value

On a technological point of view the radar still retains its original elevator, so this is an important component of the radar. Its original periscope is also retained. Most of the electronic devices were adapted in function of its radio astronomical use and essential still reusable electronic parts were removed before its journey to Raversyde.

Educational value

In the context of a museum of the Atlantic wall it's important to show how the defence of the Atlantic wall worked and this Würzburg Riese radar forms the excellent object to illustrate that side of warfare.

Similar treatments

The radar of Douvres-la-Délivrande, France

From 1992 onwards a profound research was performed by the *Laboratoire d'Archéologie des Métaux* of the *Service de Restauration des Musées de France* in function of the treatment of the Würzburg Riese radar of Douvres-la-Délivrande in 1994. The results were published in different scientific articles (Forrières & Périssère 1997, Forrières 2001). This proved to be invaluable information to build upon for writing down a treatment for our own Würzburg Rieseradar.

To take into consideration is that the radar of Douvres-la-Delivrande is situated about 2 km away from the coast and is now in need to be retreated. In 1996 a revision was done. Around 2000 it was repainted. In 2010 a close investigation of the condition was executed (Lemoine 2010).

Flightbase of Deelen – The Netherlands

On the Flightbase of Deelen a restoration project of a Würzburg Riese radar is currently going on and is completely executed by a team of dedicated volunteers who provided us with lots of valuable practical information (Museum Deelen 2015).

Physical Condition – Damage

A description of the initial damages can be found below.

Railway wagon: overall surface corrosion, but structurally sound. The wooden floor has partly rotten away and has been covered with non-original roofing.

The concrete of the supporting pilasters under the train show cracks and lacunae due to the corrosion of the iron structure.

Cabin: outside: the fine steel sheets are completely corroded with lacunae, inside: a false floor covers the original rotten wooden floor, the floor plate itself is stable. The door is a replacement. The wood of the windows has rotted. The chimneys on top of the cabin have been altered because of the second roof that was placed upon the existing roof in function of protection.

Spindle bar: was in a bad condition: on the ends completely corroded, arms are burned through, extensive corrosion due to the continuous entering of water. The drive motor is missing.

The arms are in a bad state where they have been burned off, but haven't been adapted as it is the case with many other arms of dishes used Post-war.

Parabolic dish antenna: the mirror is composed of juxtaposed aluminium beams, covered by square mesh panels. Some beams had local signs of powdery corrosion products and could break every instant. The covering paint is in a relative good state. Presence of local repairs with other materials, but in a good state. Alteration of the antenna receiver.

The aluminium parts of the parabolic antenna fastened with iron bolts, have suffered from corrosion by the potential difference of these materials. This problem is also present on the mount points of the 3 parts of the dish. In the past, reparations and alterations were executed by overlapping all mount points with plates fixed with pop rivets. The central piece of the parabolic antenna was in the worst state.

All elements covered in grease were still in excellent condition (Everaert 2015).

Treatment

Transition period at the Raversyde-site

After more than 50 years of active service, the radar was locally heavily corroded what posed problems with the demounting on the site of Humain in 2009. The bolts that fixed the arms of the parabolic antenna proved to be so stuck. Sadly it was decided to cut the arms through, also due to limited time and resources. This meant that it was impossible to re-erect the radar in Raversyde, once transported to the Raversyde-site in 2009. Hence the radar rested for some years in the dunes separated into the parabolic antenna, the control-cabin with bar and the railway wagon. To prevent further deterioration the cabin was painted on site with local application of mastic.

Finances

In 2014, sufficient funds were available through a 50% funding of the European Interreg IVA Project “World War 2-Heritage” and 50% through the investment of the Province of West-Flanders to perform a professional treatment.

Procedure of commission

Elaborate specifications were written out with emphasis on a deontological approach with respect for the originality. This rapport was published as an open public tender procedure. The treatment had to be long-term guarantied and conform the Riga and Venice Charter. All work was combined in this one procedure so that all responsibilities were concentrated within one company. The company was allowed to work with contractors that first had to be agreed upon by the museum. The treatment was divided into different lots, so that payments were made each time a lot was finalised and approved upon.

From the start, it was quite clear that the treatment would have to be much more a restoration than a conservation. This to guaranty a long-term treatment and to provide sufficient structural stability of the massive object. The treatment would focus on a profound colour investigation and documentation. And emphasises on the Second World War phase of the radar.

At the end of the tender procedure, the restoration was commissioned to the Bouwsmederij Everaert from Bredene, Belgium. It is a family company that constitutes of a father and his two sons and 2 employees with a large tradition of working with metal along the coastside, who already treated the remains of the H.M.S. Vindictive. The son Stijn Everaert is formed in restoration.

Dismantling and transport

After a thorough study of the wartime manuals, the restorers started on the site to demount the different parts for transport. This took about 2 days with 3 people. The 3 parts of the parabolic antenna were divided, but the arms were kept on. The cabin was separated from the spindle bar. The train wagon could be transported as a whole.

The transport was done in 1 and a half days’ time in close collaboration with the transport firm (3 persons) and the restorers (2 persons). A crane with a capacity of 80 ton and a telescopic crane were used in combination with 2 trailers. As practical measures, the public road nearby had to be closed down and the airport just nearby the museum site was asked permission to be able to use a telescopic crane.

Colour research

At the workshop was started with a thorough colour research of the historic paint finishes. For this the restorers collaborated with a researcher specialised in the colour research of historic interiors. The aim was to search for original markings below the existing paint layers, and to assess which were the different following paint layers on the different parts. This to make an attempt to determine which paint layer correlates with which layer of its history and to track down what were the original service colours. Samples of the original paint were retained.

The colour-layer stratigraphy on strategic spots in the form of 'windows' revealed the following sequence of colour surfaces on the cabin:

1. A dark red brown basecoat
2. a first coat in very dark blue black grey similar to RAL 7016
3. an orange-red lead minium basecoat
4. a very dark green
5. a light yellowish green
6. silvery coat
7. medium grey with a greenish tone
8. red brown basecoat
9. white
10. silver coloured paint
11. dark blueish grey

The stratigraphic results of the railway wagon were the following:

1. an orange-red lead minium basecoat
2. a dark red brown basecoat
3. a first coat in very dark blue black grey similar to RAL 7016 with on this layer white markings and numbers, one marking in dark yellow (RAL 7028)
4. an orange-red lead minium basecoat
5. medium grey
6. silver coloured paint

The two first coats (on the railway wagon the three first coats with markings) date from the War period and the last paint layer dates from Raversyde, all layers in between date from the radio astronomic period of the radar. The radar was painted monochromic and all layers were executed in oil paint (Uyttendaele 2014).

The colour layer number 2 as it's seen at this moment (with degradation, discoloration and chemical adjustment) is to be situated in between RAL 7016 and RAL 7021. RAL 7016 is the usual colour used by the German *Luftwaffe*, named *Luftwaffe Grau*. Three different metal plates were sprayed in the different RAL colours to compare and to be colour-matched with the original colour.

In the museum the radar will be presented as an example of a radar during the Second World War so there was opted to go for RAL 7016 as the executing colour. In Deelen they will also use the colour RAL 7016.

On the railway wagon could already be visually established that there were different levels in the paint layers. By the naked eye some markings could be situated, the place of others could be detained from the gathered existing documentation. It was effective to trace over most of the underlying markings with a pencil. On other places the markings had to be freed with a scalpel with a scraping technique. Several markings were retaken at a certain point of time. All markings were originally stencilled.

Further treatment

After dismantling, cleaning and restorations, with exception of the parabolic dish antenna (see further), the radar and railway wagon were completely industrially sandblasted SA 2 ½ (ISO 8501-1). This to remove any spot of corrosion still present and to give the best adhesion possibilities for the following paint coatings. This is a hard restoration and removes all original paint but is the only way to guaranty a long-term treatment of the object.

The new coating was done with an offshore protection paint system: C5-M, like they are nowadays use for windmills on sea. The whole process was executed by MultiTech n.v. Ostend that specializes in the treatment of offshore constructions.

Treatment of the cabin: The steel plates of the cabin had too many lacunae to save them and had to be replaced. This was done by cutting of the rivet heads and beat them through, to avoid damage to the structure in steel. The floorplate was completely taken out to treat all sides. Most of the mounting plates were reusable. The windows were demounted and restored. The new plates were sanded and attached following the original riveting system. Parts of the structure of the cabin had to be locally replaced, but most parts could be retained. All new parts were engraved with markings to make clear these are recent additions. The non-original second roof in aluminium was removed.

The bar with rotation mechanism: the bar was severely corroded and essential for the stability of the construction. All attacked parts were grind away until the healthy parts. Plates had to be renewed deep into the structure. Locally the plate work was welded, the hinges of one shutter were replaced and four lids.

The reduction- and transmission units still in excellent order were detached in order not to be sandblasted with the rest.

The parabolic dish antenna: the arms and turning points of the antenna were detached.

The mirror made out of aluminium was treated in a completely different way: the aluminium is quite vulnerable and thin and would be too much damaged by sandblasting. So only weak parts were replaced following the original method. All corroded iron plates were replaced. The still structurally sound old restorations were left untouched.

The attacked parts of the arms were remade.

The railway wagon: The brakes and the operating mechanism were stuck, so the bars had to be cut through and soldered again in an open stand. Crests of rust were removed with a pneumatic scraper and vibrating needles.

The roofing on the beams was taken away. The rotten beams of the wooden decking were treated or replaced and refitted.

The railway wagon proved to be too big to enter the spray painting boot, so the wheels had to be taken off.

The container that holds the radar structure mounted on the railway flatbed car has a division of four compartments with sand to keep the radar in balance. This container was detached from the railway wagon before its treatment. Some bolts had to be replaced and there was a lot of work on the profiles for the bolts to ensure the safety of the structure. The coupling rods for the coupling with the tilting axis that were burned through during the dismantling in Humain were completely stuck. Through heating by an electric arc, they finally loosened bit by bit (Everaert 2014).

Assembly of the radar on site:

To avoid any confusion that historically there never has been a radar in the battery in Raversyde, it was decided to erect the radar at the entrance of the site near the parking space. That way it functions as a reference point and teaser for the site, but it doesn't create any confusion and tells a part of the history of the Atlantic wall. It's placed as far away as possible from the seaside and one side is protected by the entrance museum building of the archaeological museum Anno 1465.

The radar was placed on an existing road in asphalt. A railway bedding was created using a dry concrete mix with railway pebbles on with concrete railway blocks and trails upon.

The different parts were assembled on site with the same transporting crew. This was spread over two days.

Because of the height of the free-standing metal structure, lightning protection was attached on the wheels of the railway wagon.

Other practical issues had to be taken into account: the distance from the airport nearby to stay out of the flight zone, the need of a building permission or not, the stability of the underground and the absence of piping or cables underneath, the protection against vandalism and physical damage, the lighting security. Also the direction of the dish antenna was matched with the predominant wind direction to guarantee the most stability.

Results

The actual treatment was completed in a 5 months time period (end of april 2014- 30th of September 2014).

During the treatment, a bullet hole in the left arm of the radar was discovered, of course this was left untouched as a proof of its history.

Maintenance

After 8 months the radar was revisited by the restorers to evaluate the treatment and to establish an appropriate treatment scheme. Weak points prove to be the spots were the radar was handled during placement and these were already prone to the first signs of corrosion. As well as all the points where the water gathers. Galvanic corrosion is seen next to the lightning protection.

To treat this, the radar will be treated and retouched locally by the restorers.

It's obvious that the radar will need regular maintenance and that will be a never ending project: monitoring, visual inspection, surface cleaning, retouching corroded areas. An annual cost and timing have to budgeted (Wain 2004).

Conclusion

The project was an exercise in equilibrium between maintaining authenticity and guarantying a long-term treatment. Restoration got hand above conservation.

Outdoor military heritage requires permanent, long-term commitment of museum staff and funds. It needs good management, but is a labour intensive and expensive aspect of collection care.

One of the effects of our restored radar, was that we were contacted by one of our German visitors: a 95 year old man was very surprised to be confronted with a similar radar as the one he worked on during the war years in Brest, a unique living testimony of history. An interview is planned.

Points of interest

With such a project it is of the greatest importance to have a preliminary elaborate report. In this report, it is pointed out what exactly is expected from the restorers. You have to ensure enough safety guaranties that the work will be done by specialists aware of the basic principles of conservation. One of the biggest dangers is over-restoration, so you'll end up with almost a new object. If this isn't possible, the whole process should be closely followed up by a conservation specialist. During treatment an intense relationship with the executer has to be established to avoid different expectations of the involved parties. Work goes fast and sometimes choices that are evident for the restorer aren't for the museum. Once a process has started it's too late to turn back the clock. Treatment of such a large objects involve quite a lot of hard, industrial techniques so it can be difficult to retain small details. In this respect choices will have to be made. The available time and cost will have a persistent say into this.

Collaboration of different specialities is a must where you can't expect to find all this knowledge in only a few people.

Biography

Since 2013 Kathleen Ribbens is the registrar and collection responsible of the Atlantikwall Museum of Raversyde, Belgium. After a Masters in Arts and Philosophy at the KULeuven she was originally formed as a textile conservator at the Academy of Arts in Antwerp coupled with a degree in paper conservation. Her main professional interest goes to the conservation of objects constituted of mixed media. She started working as a restorer in the textile workshop of the Royal Institute of Conservation in Brussels in 2005. Afterwards she worked as a scientific collaborator and collection responsible on the start of a new museum in a protected monument concerning the Coastal History of Tourism. Before coming to the

Atlantikwall Museum, she worked as an object conservator-restorer in the Africamuseum of Tervuren. In Raversyde she is now focussing on the restoration of some large military objects. Recent conserved objects included a 60 cm searchlight, an EM4mR40 rangefinder and Würzburg Rieseradar. The treatment of a PAK 40 anti-tank gun is on its way.

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Materials

Offshore protection paint system: C5-M:

First coat: Apecoat Zinc Basecoat 60 micron dry

Second coat: Apecoat Mio E93 105 micron dry

Third coat: Apecoat Mio 93 105 micron dry

Fourth coat: Acrydur HB finish A39 Satin 50 micron dry