THE ROLE OF CONSERVATORS IN THE IMPLEMENTATION OF SURVEYING TECHNIQUES - REFLECTIONS ON THE BREMEN COG MONITORING PROJECT

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Abstract

In 1962, the Bremen Cog, a 14th century ship, was discovered in the river Weser close to Bremen, Germany. After almost a decade of reconstruction and two decades of conservation, the ship was presented to the public in May 2000. Unfortunately, one year later the first deformations were noticed, and corrections had to be made. With the help of a European expert panel, a second support system was designed and presented to the museum's board in 2006, but never implemented. After reshaping the ship to its "original" shape, staff retired one by one and the project was not completed.

In 2013, it became clear the ship and its deformation processes had to be better understood. This was the foundation stone of the Bremen Cog's deformation monitoring project. Starting with the support of an EU-COST-Action, several studies were conducted using different measuring methodologies. The aim was to identify the best method. Consequently, the German Maritime Museum decided to fund a PhD fellowship. In 2016, the PhD started and a partnership with the Institute for Applied Photogrammetry and Geoinformatics (IAPG), at the University of Applied Sciences in Oldenburg, became one of the project's pillars.

Deformation monitoring is a preventive conservation measure; the collected data delivers information to plan the future support system as well as keeping an eye on the ship. This paper presents the work done in setting up the goals, assessing the first tests and results, as well as developing the final measuring system to monitor the Bremen Cog three-dimensionally. The role of a conservator in developing a deformation monitoring system and the additional knowledge and skills necessary is also described in this contribution.

Keywords: 3D monitoring; photogrammetry; archaeological ship; Bremen Cog; long-term preservation; condition assessment; museum presentation; archaeological wood.

Introduction - short overview of the Bremen Cog's history

In 1962, the Bremen Cog was discovered, covered in sediment, close to Bremen, during the extension of the harbour in the river Weser. The 14th century ship was a sensational discovery and is still very important in terms of the history of Northern European ship building. Beyond representing the symbol of the Hanseatic League, the medieval vessel was the first ship from that period recovered in an archaeological context (von Brandt, 1968). After a complicated excavation between 1962-1965 in the troubled water of the river, the dismantled ship timbers were stored in water while the reconstruction and conservation projects were planned and the money secured. Her final destination was agreed upon and the German Maritime Museum was founded in Bremerhaven to host the ship, about 60 km from where she was discovered. The reconstruction occurred under the supervision of the boat builder Werner Lahn. It was conducted in the very same room where the ship would later be conserved in a large tank and where she is displayed today. The Bremen Cog was the subject of many studies on PEG treatments and archaeological waterlogged wood degradation conducted by Dr Per Hoffmann, wood chemist, researcher, and head of conservation at the German Maritime Museum in Bremerhaven from 1979 to his retirement in 2008.

After 19 years of conservation, the ship was officially presented to the public in May 2000 (Figure 1). When the exhibit opened, everyone believed that the work was done, but the preservation of the ship was more challenging than expected. Soon after the opening, Hoffmann observed the first deformations showing that hanging the ship from the ceiling was not providing enough support to the treated wood and that the support system had to be reassessed (Hoffmann, 2011). From 2002 to 2008, a new support system was designed and proposed, but for ethical reasons never implemented.

In 2013, a workshop was organized at the German Maritime Museum to discuss future presentation and a new exhibition around the medieval vessel. All the specialists agreed that the deformation processes needed to be better understood before further steps were taken. After some preliminary tests supported by the European Cost-Action[1] – Colour and Space in Cultural Heritage (COSCH) - the museum decided to fund a PhD Fellowship in conservation to look into the deformation monitoring.

In November 2015, the fellowship's goals were described in the job announcement as studying the "possibilities and limits of modern non-invasive documentation technologies to survey long-term behaviour of large museum objects (…) in a close dialogue with the engineering field, in order to apply 3D methods to conservation problems."

Figure 1: Bremen Cog current situation in the German Maritime Museum, Bremerhaven (2018, A. Colson).

Project aims

As stated in the fellowship announcement, the project aimed to adapt 3D technologies for the long-term preservation of large museum objects. The use of 3D technologies in cultural heritage is common, and it has become a standard for documentation in archaeology or architecture (Stylianidis and Remondino, 2016). But so far, in conservation the use of 3D technologies is still sporadic. Since the spectrum of measurement techniques available is large and the applications are very promising, the research project aimed to identify the most suitable method to acquire the geometry of large objects in museums and monitor structural changes over time. Both, the technical capabilities of the method and the museum's particularities played a role in the selection of a method. The museum's board had one requirement: "keep the cost as low as possible for the best results possible," which illustrates the difficulty of high expectations and low available resources in the museum field. Beyond this non-scientific criteria, the method was to be integrated in a global preventive conservation approach, and take into account the museum's infrastructure (finances, staff, equipment). Additionally, sustainability was added as another component, since 21st century museums must become more conscious of how resources are used. In this context, sustainability in museums was understood on two different levels. First, considering the lack of continuity in employment and the enormous turnover in personnel due to short-term contracts, financial resources must be wisely used, and the same job should not be done several times. Second, museums must be more ecologically sustainable and develop strategies to reduce carbon footprint in reducing management costs such as maintenance (Cousins, 2016). The need to pay close attention to the condition of archaeological ships in museums has been clearly established (Colson *et al.*, this volume), but the question of "how" to monitor and the role of conservator in this process are the focus of this contribution.

The doctoral study was conducted and funded by the German Maritime Museum in Bremerhaven, with the scientific supervision of Professor Dr Mona Hess, University of Bamberg and Professor Dr Thomas Luhmann, Jade University of Applied Science Oldenburg. The Bremen Cog was chosen as the case study to develop a measuring system able to acquire geometrical information over time fitting to the conservation goals.

The Bremen Cog deforms

In May 2000, the Bremen Cog exhibition at the German Maritime Museum opened to the public. Unfortunately, one

[1] European Cooperation in Science and Technology funding organization for research and innovation networks

year later the first issues appeared and some deformations were noticed, justifying a new support system (Hoffmann, 2011). The 14th century ship was exhibited free standing in the room, with some key points held from the ceiling (24 m long, 7 m high and 7.5 m wide weighs up to 40 tons). Sadly, the "elegant (..) hanging system appeared unsuitable" (Hoffmann, 2010) (Figure 2).

In 2003, a photogrammetric acquisition was conducted to evaluate the scale of the deformations. The data was compared with measurements from the 1980s, before conservation, and a deformation of 10 to 25 cm was identified (Wiggenhagen *et al.*, 2004). Between 2002 and 2006, Per Hoffmann and a European group of experts, museum staff and external panel, developed a support system based on the principle of "correcting the deformed hull according to drawings of Werner Lahn; holding the corrected shape; a made-to-measure steel construction, fixed on the ground and to the ship" (Hoffmann 2010). In 2007, the ship was "reshaped" on circa 100 local points using the 30 metal beams installed around it, still in place today and often mistaken for a support (Figure 1). The new support system proposed was very invasive and was considered ethically debatable, and for that reason never implemented. All staff members involved with the project eventually retired one by one, leaving the project uncompleted.

The discussion of the hull's "correct" shape is still going on. However, archaeologists now consider that the ship went through so many changes that one can definitely not speak about any "original" shape anymore (Tanner and Belasus, 2018). This means that the ship should stay in the current shape and that deformation processes should be understood before designing a new support system. Since any new support would have very high costs, deformation monitoring offers knowledge-based information that will enable proactive decision making and adequate planning.

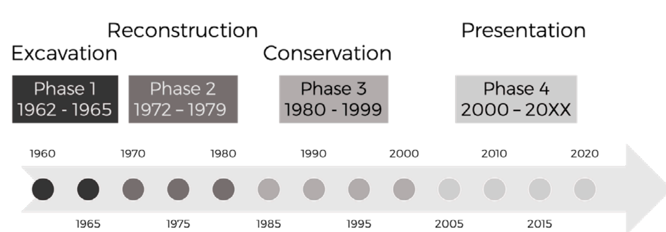

Figure 2: Bremen Cog project – time line (2019, A. Colson).

Spatial monitoring of the Bremen Cog

The Bremen Cog has been surveyed many times since the 1980s with various measuring techniques and with different goals. Although a lot of data has been produced and gathered, it does not mean that it fulfils the aim of deformation monitoring.

It is important to distinguish between digital documentation and deformation monitoring. The design of a monitoring system requires much more attention and diligence than a one-off digital documentation. The goal of digital documentation is to make the object available, but the use of the data can be plural: for the specialist to conduct measurements, for the public to learn more, for the museum to disseminate news and information about an on-going project. The fact that a dataset can be used for different purposes is not necessarily clearly understood by museum professionals yet, moreover the monitoring activity needs to be integrated from the start into the museums work (Colson, 2017; Prescott and Hughes, 2018). For digital documentation, the acquisition is performed once and the level of accuracy is dictated by the users and / or their needs. For deformation monitoring on the other hand, everything must be defined from the start to achieve the long-term objectives. Like in conservation, every step of the process has to be carefully thought through, and sometimes certain compromises have to be found, when the initial goal cannot be met (Colson, 2019).

The first goal was to find the appropriate technology to acquire the ship's geometry considering the given constraints. Secondly, to develop a measuring protocol, a clear procedure enabling data comparison over time, where acquisition repeatability, data format and data processing had to be specified. Between 2014 and 2016, three methodologies have been tested on the Bremen Cog:

1) Total Station Theodolite with live visualization; used by ship archaeologists, performed by Massimiliano Ditta;
2) Terrestrial 3D scanning, performed by i3Mainz Institute for Spatial Information and Surveying Technology from the University of Applied Sciences in Mainz, Germany; and
3) Photogrammetry/Structure from Motion (SfM) using the commercial software Agisoft-Photoscan, performed by Julien Guery. Some tests were also conducted to compare the data, performed by Levente Tamas, University of Cluj-Napoca, Romania.

This work was conducted as part of a case study for the EU-COST Action Colour and Space in Cultural Heritage (COSCH) (Colson and Tamas, 2017).

In 2016, as the PhD fellowship started and the partnership with the Jade University of Applied Sciences, Institute of Applied Photogrammetry and Geoinformatics (IAPG), in Oldenburg was initiated, an evaluation of the collected data was conducted by Heidi Hastedt and Thomas Luhmann (Hastedt and Luhmann, 2018). In this process, the objectives were also revised, and several meetings were dedicated to sharing knowledge, information and ideas. As a result of fruitful discussions, the decision was made to choose photogrammetry, a measuring technique based on photographs (Hastedt *et al.*, 2019).

In the summer of 2017, thanks to an M.A. thesis from Jurij Schmik (IAPG) and additional analysis within a feasibility study, a protocol was defined that was statistically able to detect deformation of about 1 mm on the Bremen Cog (Schmik *et al.,* 2018; Hastedt *et al.,* 2019). With respect to the feasibility study, the detection of deformation with this high-quality level was found to be mainly dependent on the coordinate system, i.e. an independent network around the object with control points fixed in the building walls.

Today the monitoring includes:

1) 22 control points fixed in the building to establish a three-dimensional invisible box and enable a coordinate system or ground control network,
2) 120 reflective targets on the ship adhered with Japanese paper with wheat paste adhesive
3) 450 coded tie points recognized automatically by the software to secure the data processing.

The photogrammetric acquisition requires a digital camera and takes 2-3 hours if the operator is familiar with the procedure and the system. An acquisition can be performed by a trained non-expert. Latest analyses indicate that a significant detection of deformation of a few millimetres on every target point on the surface is realistic. The original goal was to reach statistically significant single point accuracy to the order of 1mm to enable the detection of deformation, which now must be put in perspective due to use of the ground control network. The influence of tides in the river mouth on the ground control network is still not quantified, which makes the network less reliable than previously thought.

Role of a conservator in designing a deformation monitoring system

Conservators have been held in a negative light by some museum professionals, although their expertise and know-how are absolutely essential and well established. Their critical attitude has sadly been perceived as "problem making." Murray Frost even called conservators "pedantic nay-sayers" and showed how this negative image affects conservators work and interactions with their colleagues, as well as with their superiors (Frost, 1994). Developing deformation monitoring is an opportunity to change how conservators are perceived. Using robust scientific knowledge and metric evidence to support the decision-making process is the key to make museum directors finally aware that conservators are "problem solvers."

Over the course of the PhD fellowship, a communicative bridge was built between geodetic measuring experts and conservators. The willingness to understand the other's field and its challenges came from both sides. However, diving into the scientific reasoning and reading the literature dedicated to surveying, metrology and geodesy, has helped the conservator (A. Colson) tremendously to define the level of detail necessary to design a deformation monitoring system (i.e. the activity of monitoring at given time intervals). Being able to be open-minded but also have enough background knowledge to discuss actively with the engineers, guaranteed an appropriate measuring system.

To participate actively in the design of a deformation monitoring system, the conservator needs not only technical and manual skills, but also appropriate soft skills. Although, skills such as communication, project management, problem solving qualities, are rarely taught in conservation programs, some professionals advocate their relevance within an efficient preventive conservation practice (Wickens and Norris, 2018).

Working in an interdisciplinary research group is not as effortless as one wants to believe and requires time and diligence, but can provide satisfying results, when conducted wisely (Brewer, 1999). Cultural particularities inherent to each discipline have to be overcome and consciously dealt with. More dialogue between the experts and users is needed to integrate geodetic measuring systems into the conservation of cultural heritage (Haddad, 2007). Equally, capacity has to be built in museums to enable conservators to be innovative and change their workflows (Hess *et al.*, 2018). Only then, can the cooperation be fruitful.

Conclusions

We confirmed that deformation monitoring was helpful and effective, when it is seen as part of preventive conservation measures. However, every case is unique and designing a spatial monitoring system requires time and effort. The main challenge lay not in the technical feasibility, but in the museum infrastructure and management, such as personnel, equipment, know-how and budget. Infrastructure must be optimized to fully integrate deformation monitoring activities in the conservator's workflow. The objectives must be defined by conservators, to guarantee the sustainability of the system, since they are the end-users, but a close cooperation with experts in geodetic measuring systems is crucial. The use of 3D technologies in cultural heritage has developed rapidly and most conservation professionals have not been trained yet. The lack of capacity must be overcome by workshops and training measures still to be developed.

The Bremen Cog deformation monitoring system uses photogrammetry. The methodology has proven to be reliable in performing deformation monitoring and deemed an adequate alternative by experts in the field. The system will hopefully be implemented by the German Maritime Museum in the future, although the director's authorization is still pending at the time of writing this contribution.

Acknowledgments

We would like to thank: Pat Tanner, from 3D Scanning Ireland, for sharing his experience in boat building; and Mike Belasus, Saxo Institute, Copenhagen University, for his insights in ship archaeology. Also, the Jade University of Applied Sciences and especially the Institute of Applied Photogrammetry and Geoinformatics for their support. The German Maritime Museum for funding this research. As well as all the participants from the EU-Cost Action: Colour and Space in Cultural Heritage (COSCH), moreoever Stefanie Wefers (grant holder).

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Q and A

SHANNA DANIEL: I do have a question about the photogrammetry part of things and the staffing with that. So, you started that in 2014. I know it takes a lot of time to do that especially with something that big with the museum corporation, do you go back and continue over time and how is the museum handling that when you do go back?

AMANDINE COLSON: When we started in 2014, we were running different sorts of tests. Then we decided on photogrammetry for different reasons. We designed the project that the Oldenburg University would be still a partner and still part of this whole thing over 10 or 20 years so that was important. The preliminary research done was on how many points to use. This was mostly tackled by a Master's thesis from the University of Bradenburg, so all the research behind it has been conducted by them to help us in designing the protocol. The idea is that we would not process the data,ooking for links at different times between the deformation and the climateoo but a normal person (a non-expert person) could take the pictures (we are talking about 400 pictures) and then they would process the data. We are not using average software to do this. It is a custom-made software program designed by the University of Oldenburg because we want to be in control in the data processing so we don't want to use any commercial software for that.

ELEANOR SCHOFIELD: When you said that the deformation was 10-25 cm is that movement as in forward movement or shrinkage or lateral movement).

AMANDINE COLSON: It is a little bit of everything so what we are seeing now is that the ship is moving towards one side and also towards the front as well. We can see some trends, but this is too early to get into the analysis because we don't have enough data yet. So, this has to be done. And the question is if the protocol is going to be implemented because the museum is currently debating. Hopefully, all this work will not be in vain and the protocol will be implemented but this is not clear yet.