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Measurement of Installation Art
Methods and experience gained at Pinakothek der Moderne

Special study within the European Research Project
"Inside Installations. Preservation and Presentation of Installation Art" (2004-2007)

38 pages

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Contents

1 Introduction

With the move of the Sammlung Moderne Kunst (Collection of Modern Art) from Munich's Haus der Kunst to the newly built Pinakothek der Moderne in 2002 Joseph Beuys' 'Das Ende des 20. Jahrhunderts' ('The End of the 20th century') became the collection's first installation artwork[1] to be measured geodetically. Since then installation art belonging to the Sammlung Moderne Kunst has being documented in this way. The surveying work has been carried out using various methods and has resulted in a number of documents, such as floor plans and different views of the particular installation.

Documentation

The primary objective of these measurements has been to document the artwork. Installations usually consist of several objects whose impact and significance is decisively influenced by the way they are arranged spatially. A geodetic survey provides highly accurate and fixed coordinates for every object. By referring to one subordinate zero point the plans form a closed system that can be transferred to a different location without the need to make any changes. By contrast, hand drawings based on visual judgement, photographs or video recordings can only define the exact locations of the objects to a limited extent, thus leaving room for interpretation.

Fig. 1: Pipilotti Rist and her assistant Davide Ciresa setting up the installation at the Pinakothek der Moderne in August 2002.
Fig. 2: 'Himalaya Goldsteins Stube' shown at the Pinakothek der Moderne in 2002.

The installations hitherto measured in our museum have been set up by the artists themselves or by a representative, as was the case with Pipilotti Rist's installation 'Himalaya Goldsteins Stube' ('Himalaya Goldstein's Living Room'), 1998-99 (Fig. 1; 2). This artwork, which is made up of hundreds of objects, was arranged over an area of approximately 200 square metres. After being on show at the Pinakothek der Moderne for one year it was dismantled in 2003. Now, packed away in some 100 units such as crates and boxes, it is scattered over several storage locations in the basement of the Pinakothek der Moderne. This example shows how important the registering of these "original" arrangements is in order to document the history of the artwork.

[1] As well as the term "installation art", this paper also refers to "sculptures" and "environments". What these works all have in common is the fact that they are made up of a number of objects arranged in a particular way – one that is determined by the artist. It is not possible here to discuss in depth the different definitions of this genre. For the purpose of this study, the expression "installation art" is used as the generic term, since the focal point of the observer's attention is centred on the relationship of the artwork to the space/room around it.

Reinstallation
All the time the installation artwork is stored away, its spatial context does, of course, cease to exist. So plans may well provide the definitive basis or at least be a useful guide in the event of subsequent reinstallation. For many artists, it is important that their work undergoes change. Pipilotti Rist, for instance, bases her assessment of the plans on where the reinstallation is to be staged. This is a point that will be referred to later.

Certification
In some cases plans are needed for certification. This will be shown with the case example of Fred Sandback's 'Sculptural study for the Pinakothek der Moderne (Mikado)', 2003.

The following examples of surveys carried out in the Pinakothek der Moderne will illustrate different approaches and results relating to the different needs of the artworks by the artists Joseph Beuys, Fred Sandback, Pipilotti Rist, Mark Manders, Thomas Hirschhorn and Olaf Metzel. Only brief reference will be made to the individual methods of measurements at corresponding points in the report. Here it is worth noting the compilation "Verfahren und Instrumente zur Vermessung von Rauminstallationen – ein Überblick" ("Overview of possible techniques and instruments for measuring room installations", available only in German) described by Alexandra Czarnecki in the special study within the European Research Project "Inside Installations. Preservation and Presentation of Installation Art" (2004-2007) and also published on the Internet at: www.inside-installations.org.

2 Case examples of measurements

2.1 Joseph Beuys 'Das Ende des 20. Jahrhunderts' ('The End of the 20th century'), 1984: Tachymetry[2]

Date of measurement: January 2002
Carried out by: Weller Vermessung, Dipl.-Ing. Peter Weller, Waltenhofen

Artwork
'Das Ende des 20. Jahrhunderts' ('The End of the 20th century') (Fig. 3) by Joseph Beuys (1921-1986) consists of 44 basalt columns with lengths varying from 1.20 to 1.80 metres. They are arranged over an area of some 69 square metres.[3] Most of the stones are laid out flat on the floor; some lie lop-sided on top of each other, with two others resting on the remaining stones. There is only one stone that is upright, towering up on its narrow end. A cone-like shape was cut out at one end of each stone. These cones were re-inserted into the hollows using clay and, in most cases, with strips of felt added. "This gives the appearance of round 'eyes' protruding from all the stones. Felt and clay, the commonly used aggregates of warmth in Beuys' material cosmos, also create the impression of having given new life to the ancient stones. Seen from this animistic viewpoint, the stones suddenly seem like one-eyed archaic beings from the Prehistoric Age. [...]."[4]

Fig. 3: 'Das Ende des 20. Jahrhunderts' in the Haus der Kunst, 1984.

Joseph Beuys arranged the 44 basalt stones in Munich's Haus der Kunst, which at that time housed the collection. They were exhibited in the same room there without changes until the move in 2002.

[2] The word "tachymetry" derives from the Greek language and means "quick measurement". It is a geodetic method that is used to measure the earth and land by determining angles and distances in order to specify the coordinates of a point within a three-dimensional space. The instrument used for this is a tachymeter. It consists of a theodolite, which is a telescope equipped with an angle gauge, and also a device for measuring distances that uses a laser beam or infra-red light.
[3] The 69 sqare metres refer to the size of the square within which the stones were positioned.
[4] Pinakothek der Moderne. Malerei, Skulptur, Neue Medien, ed. Carla Schulz-Hoffmann, Pinakothek-Dumont, Cologne 2002, p.50.

Measurement and relocation

The artwork was then relocated to the newly built Pinakothek der Moderne, the construction of which was completed in 2002. A decision was taken to retain the spatial arrangement of the 44 basalt pillars. Bruno Heimberg, the then Director of the Doerner Institut, suggested commissioning geodetic surveyors to measure the installation of the objects so that their exact positioning could be established to the very last millimetre. This task was assigned to the surveyor Peter Weller[5]. A particular requirement was that all the operations – the measurement of the installation at the Haus der Kunst, its dismantling, transportation and reinstallation at the Pinakothek der Moderne – should go hand in hand with each other. This involved two parallel teams working on the project at the same time. So while one was occupied with measuring and dismantling the stones at the Haus der Kunst, the other team was busy setting up the installation at the Pinakothek der Moderne.

In addition, a method had to be used for the surveying that did not necessitate attaching pass points to the stones.[6] For this reason, as a first step, a digital photograph of each basalt pillar was taken. Conspicuous features of the stone, such as small depressions or changes in colour, were defined as measuring points and marked on the digital photograph (Fig. 4). These were then surveyed with the aid of a tachymeter (Fig. 5).

Fig. 4: The defined measuring points belonging to stone number 10 seen on the photograph as small numbered crosses.
Fig. 5: Taking surveying measurements at the Haus der Kunst. The operator is standing at the tachymeter (right) and taking the bearings of the prismatic reflecting surface, which is held by a prism bearer at a measuring point.

The data measured at the Haus der Kunst was then read into the tachymeter by the surveying team working at the Pinakothek der Moderne. The men who moved the stones were directed by the surveyor operating the tachymeter to the exact position of the stone (Fig. 6). The last few

[5] Peter Weller, Die Umsetzung der Münchner Installation 'Das Ende des 20. Jahrhunderts' von Joseph Beuys aus geodätischer Sicht / The relocation of Joseph Beuys' Installation 'The End of the 20th century' in Munich from a geodetic point of view, in: Joseph Beuys. 'Das Ende des 20. Jahrhunderts' / 'The End of the 20th century'. Geschichte eines Kunstwerks / A Work of Art and its History, edts. Susanne Willisch, Bruno Heimberg, Schirmer/Mosel, Munich 2007, pp. 161-171.
[6] Earlier trials with different kinds of adhesive to fix the pass points turned out to be unsuccessful. Either they left traces of adhesive on the porous surfaces of the stones, or the stones suffered damage when attempts were made to remove the adhesive from the surface.

millimetres always took the longest time. This applied in particular to the "upper" layers of stones which were lying on top of one another. Here, it was especially important to find the exact point of contact as otherwise the position of a stone would have changed considerably if it tilted. All in all, over a period of three days (and partly nights) the stones were measured one by one at the Haus der Kunst and then transported to the Pinakothek der Moderne, where they were installed in their new setting (Fig. 7).

Fig. 6: Relocation to the Pinakothek der Moderne, 2002.
Fig. 7: 'Das Ende des 20. Jahrhunderts' after relocation, 2002.

Documents

The documents in our archives consist of a layout plan on a scale of 1 to 10 (Fig. 8; 9) and a list of the coordinates of each measured point. In addition, there is a digital photograph of each stone, on which all measured points are marked with their ID number.

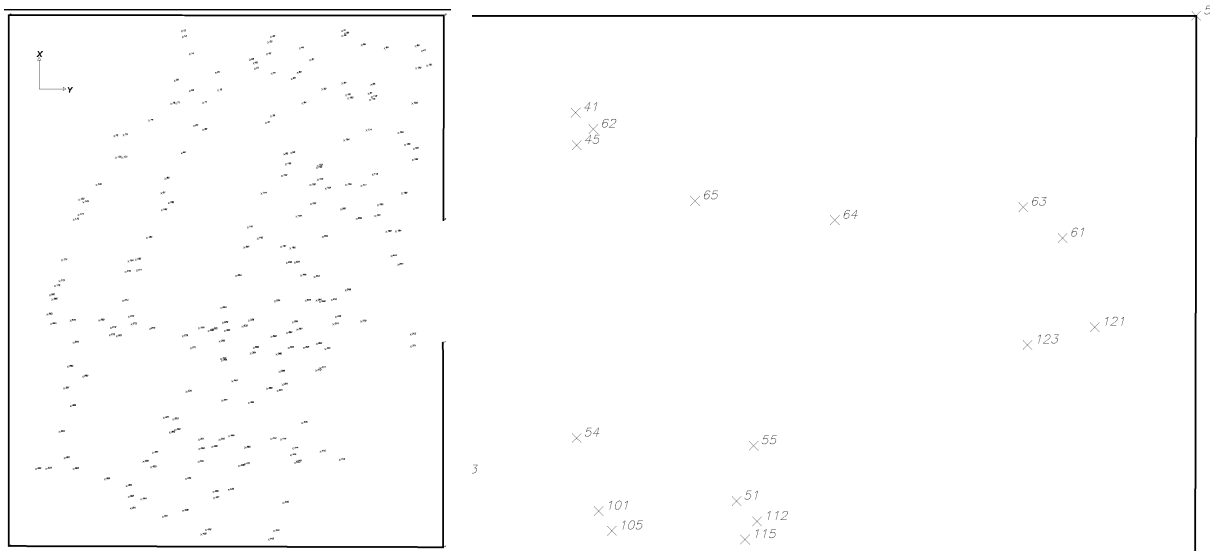


Fig. 8: Layout plan of the artwork's position in the Haus der Kunst. The positioning of each stone is defined by five crosses and its corresponding number.
Fig. 9: Layout plan, detail of the top right-hand corner. The crosses with the numbers 61 to 65 define the position of stone number 6.

Evaluation

Peter Weller concluded that "under the given circumstances this classic surveying technique with the tachymeter turned out to be the best solution [..]."[7] There were no problems or major time delays when the assembly team came to read into the tachymeter the data that had been provided by the dismantling team. This was very important for ensuring that the entire relocation process went off smoothly. By using this method we were able to achieve a high degree if accuracy for the new positioning of the stones. However, there were slight deviations of up to 3-5 mm which derived principally from the "[...] contrasting types of floor surface in the Haus der Kunst (uneven Solnhofen slabs) and the Pinakothek der Moderne (flat and polished terrazzo floor) [...]."[8]

[7] Ibid., p. 170.
[8] Ibid., p. 171.

2.2 Pipilotti Rist 'Himalaya Goldsteins Stube' ('Himalaya Goldstein's Living Room'), 1998/99: A combination of tachymetry and digital photogrammetry[9]

Date of measurement: August 2003
Carried out by: Weller Vermessung, Dipl.-Ing. Peter Weller, Waltenhofen

Artwork

'Himalaya Goldsteins Stube' (Fig. 2; 10) by the Swiss artist Pipilotti Rist (born 1962) is a wallpapered, enclosed area covering some 200 square metres. It represents a home-living interior with furniture, lamps, books, clothes and all kinds of other objects arranged within it. Video projectors are integrated into several pieces of the furniture. Dimmed lighting, soft music and comfy sofas evoke a relaxed and cosy ambience. „In the same way that someone in a world of magic appears to have reached the empire of his dreams but in reality has found nowhere at all, so one's seduction to a setting of unexpected leisure in 'Himalaya Goldstein's Living Room' is dangerously confused because contrasting and spectacular impressions both overwhelm and disorient the observer: After all, who wants to sink back into the sofa once they have seen on it the yellow flames shooting out from the video projection?"[10]

Fig. 10: 'Himalaya Goldsteins Stube' at the Pinakothek der Moderne, 2002. A video depicting shooting flames is projected on to the red sofa.

[9] As the name already implies, photogrammetry is a method of measuring images. Photographs taken with a measuring camera are equalised by means of a special computer programme so that they can then be shown true to scale.
[10] Pinakothek der Moderne. Malerei, Skulptur, neue Medien, ed. Carla Schulz-Hoffmann Pinakothek-Dumont, Cologne 2002, p. 308.

Measurement

Aim of the measurement was to document the arrangement of 'Himalaya Goldsteins Stube' including all objects, the wallpapered walls and a temporary construction next to it. Technical information such as the routing of the cable ducts or projection paths of the video beamers was also recorded. The tachymetric surveying provided coordinates of all the larger objects. Photogrammetry was used in cases where the objects were either very small or arranged so closely together that a structured overview was not possible. Instances of such detail within the installation included the laid dining table and the arrangement of several shoes. As a consequence, the tachymetric measurement of all these objects would have been too time-consuming and thus too expensive.

Peter Weller adopted the following procedure for measuring the installation: the geometric key points such as the walls, corners of the carpets and furniture, and bases of the lamps were measured with the aid of a tachymeter (Fig. 11). Similarly, four fixed pass points around the details, which subsequently had to be photogrammetrically registered, were measured with the tachymeter. These details were then photographed with a high-definition digital measuring camera[11].

Fig. 11: Tachymetric measurement of the key points. Here, one of the corners of the carpet.

Subsequent editing on the computer fed the tachymetrically recorded coordinates into a CAD programme and produced a floor plan from it. The images from the measuring camera were then read in and equalised true to scale by means of an equalising programme[12] (Fig 13; 14).

[11] Fuji S2 with calibrated objective.
[12] "Elcovision 10"by the Swiss firm PMS.

Documents

The Doerner Institut now has overview plans (Fig. 12) of various scales (1:25 and 1:50) as well as lists of the coordinates of the measured objects. In addition, there are seven detailed photogrammes on a scale of 1 to 10 (Fig. 14). The details can be clearly allocated, as it is possible to identify their pass points on the overview plans.

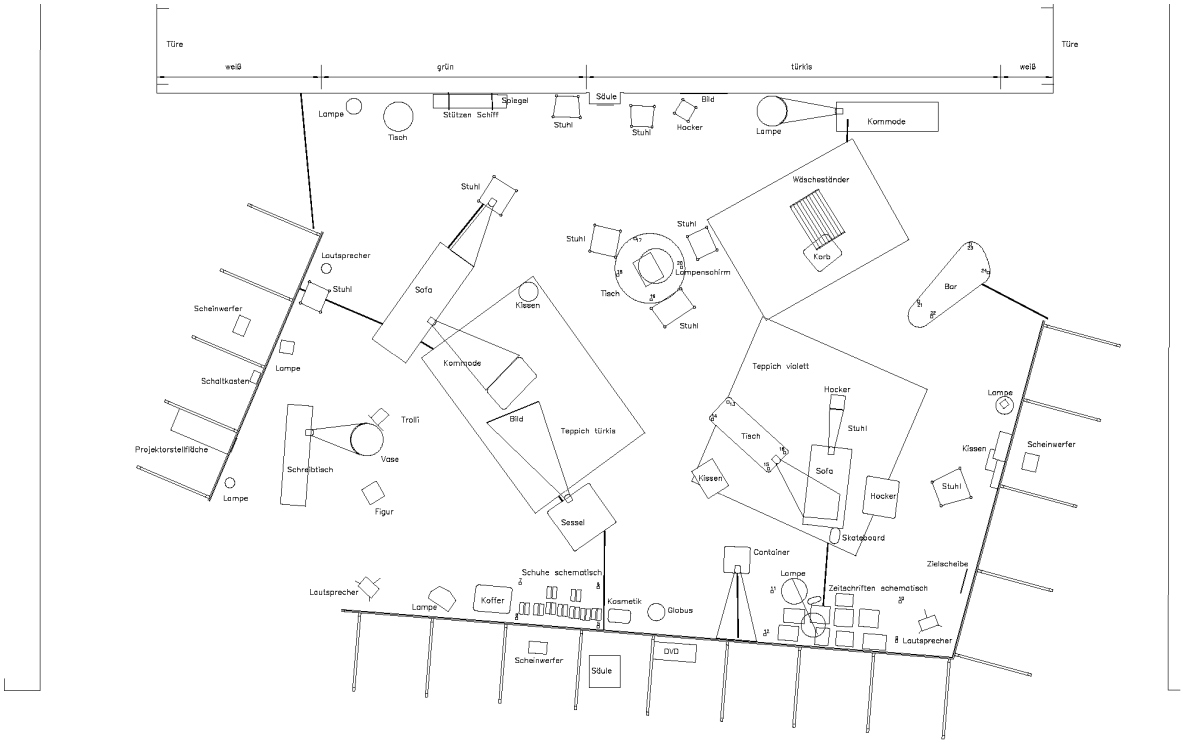


Fig. 12: Overview plan of ‚Himalaya Goldsteins Stube' with integrated projection paths and cable ducts.

Fig. 13: The photo of the circular dining table, taken with the measuring camera, before equalising to scale.
Fig. 14: Photogramme of the dining table as a result of equalising true to scale. Equalising relates only to the two-dimensional surface of the table top. Here, the distances between the objects are represented true to scale. The pass points (labelled in black and white) can be found on the overview plan (Fig. 12).

Evaluation

The combination of tachymetry and photogrammetry proved to be an efficient method in the case of 'Himalaya Goldsteins Stube'. The measurement of the geometric key points of the installation and the production of the photos required a total of eight working hours on the part of the geodetic surveyor and an assistant, including setting up and dismantling of the equipment. Approximately 16 hours were needed for editing on the computer to produce the plans.[13]

Pipilotti Rist is basically in favour of the measurement:

> „Vielen Dank. Ich begrüße Ihre geodätischen Vermessungen. Ich liebe die Wissenschaft und im Speziellen die Mathematik. Das Ganze verunmöglicht ja nicht, daß bei einer neuen Installation Änderungen und Zusätze gemacht werden, aber die Basis ist seriös definiert".[14]
> ("Thank you. I welcome your geodetic surveying. I love science, and mathematics in particular. This does not mean that as a whole it is impossible to make changes and additions in the event of a new installation; however, it has a solid basis.")

Whether the plans form the basis for a reinstallation of 'Himalaya Goldsteins Stube' and who in that event should supervise the setting up are issues she makes dependent on the choice of room:

> „Falls die Installation im gleichen Raum und gleichen Ort gezeigt wird, würde ich vorschlagen, sie nicht zuletzt Dank Ihrer Supermessungen möglich, gleich zu installieren. Falls in einem anderen Raum angepeilt, würde ich oder/und eine Person meines Vertrauens gemäß Vertrag eine neue Adaption vorschlagen."
> ("If the installation is to be presented in the same room and at the same location, then I would suggest setting it up in the same way – not least of all because your super measurements make this possible. If, though, a different room is envisaged, I and/or another person entrusted by me with the project would propose a new adaptation in accordance with the contractual agreement.")[15]

Pipilotti Rist's unequivocal views on the subject leave no doubt as to how the plans for any future installations should be managed.

[13] Information from Peter Weller to Christina Spaarschuh on 24th August 2005.
[14] Pipilotti Rist in a questionnaire by Christina Spaarschuh and Maike Grün, email reply on 25th August 2005.
[15] Ibid.

2.3 Fred Sandback 'Untitled (Mikado)', 2003: Method A: "Simple means"; Method B: Tachymetry; Method C: Hand measurement taking into account deformations

The case study of Fred Sandback's 'Untitled (Mikado)' was measured with help of three different methods in order to have a comparison.

Method A: "Simple means"
Date of measurement: November 2003
Carried out by: Dipl.-Rest. Maike Grün, Dipl.-Rest. Stephanie Thielen

Method B: Tachymetry
Date of measurement: November 2005
Carried out by: Weller Vermessung, Dipl.-Ing. Peter Weller, Waltenhofen

Method C: Hand measurement taking into account deformations
Date of measurement: March 2006
Carried out by: Alexandra Czarnecki[16], Dipl.-Rest. Maike Grün

Artwork

Spanned across a square room at the Pinakothek der Moderne with a floor space of approximately 10 times 10 metres are five lengths of taut black acrylic yarn (Fig. 15). The ends of the yarn disappear seamlessly into the architecture, their spatial arrangement creating sculptural dimensions. The "stretches of yarns run from floor to wall in such a way that viewers may be forgiven for thinking they are in an outsize game of Mikado. The black lines enduringly evoke that brief moment when the heap of sticks collapse to form a new (dis)arrangement on the game board."[17] Fred Sandback (1943-2003) commented on his use of yarn: "It's a very basic way of expressing yourself. It is not too encumbering. I'm lucky to have a medium that allows me to stay light on my feet. It really is like a drawing."[18]

Fig. 15: 'Untitled (Mikado)' installed at the Pinakothek der Moderne, 2003.

[16] Conservation student, Technical University Munich.
[17] Corinna Thierolf, Fred Sandback's 'Sculptural Studies for the Pinakothek der Moderne', in: Fred Sandback, edts. Friedemann Malsch, Christiane Meyer-Stoll, Hatje Cantz, Ostfildern 2006, p.191.
[18] Fred Sandback in a telephone interview with Joan Simon on September 1, 1996, in: Fred Sandback, edts. Friedemann Malsch; Christiane Meyer-Stoll. Hatje Cantz, Ostfildern 2006, p.135.

Shortly before his death in the summer of 2003, Fred Sandback produced his ‚Sculptural Studies for the Pinakothek der Moderne', to which the 'Untitled (Mikado)' belongs. He conceived these studies for selected rooms at the Pinakothek and recorded them in drawings. He did not live long enough to witness for himself the setting up of the installation in the autumn of 2003. Instead, it was left to his widow Amy Sandback and Dr. Corinna Thierolf, curator at the Pinakothek der Moderne, to interpret his drawings and set up the artwork according to his instructions.

Measurement

The thus established arrangement was recorded on plans. This had been requested by the Doerner Institut for documentation purposes and similarly by Amy Baker Sandback, as representative of the Fred Sandback Estate (New York City), for certification of the artwork.

Parameters to be measured during the survey included the dimensions of the room, the lengths of the yarn and the positions of the ten anchor points where the yarn disappears into the wall and the floor.

Method A: "Simple means"

As these requirements did not appear on first view to be particularly complicated, we decided to do the measuring ourselves with simple equipment: namely a tape measure, cord, a sand bag, a plumb bob, a manual electronic range finder (Fig. 16) and the manpower of two, and at times three conservators.

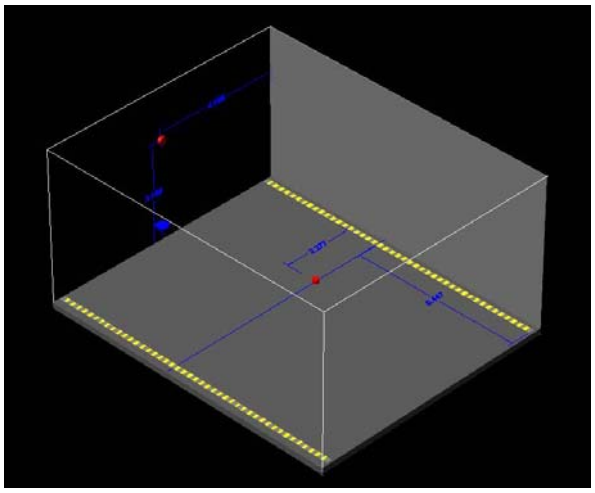


Fig. 16: Equipment used for Method A.
Fig. 17: Scheme of how to proceed. The anchor points to be measured are in red.

It should be pointed out that this method does not have any scientific basis. The anchor points of the artwork situated on the floor were measured by fixing a measuring tape along two opposite walls (Fig. 17). A cord was spanned at right angles from the graduated tape to the respective anchor point on the floor. One dimension could thus be directly read off the tape and the other was measured along the cord with the range finder. To measure the anchor points situated on the wall, a point was plumbed to the floor from each of them. The range finder was then used to measure the distance between this point (on the floor) and the anchor point and to the next wall.

The length of the yarn was determined by the range finder only (Fig. 18).

Fig. 18: The sand bag serves to stabilize the focusing of the range finder parallel to the cord.

Method B: Tachymetry
Peter Weller carried out the survey tachymetrically by registering all necessary points of the room and objects with the tachymeter (Fig. 19; 20).

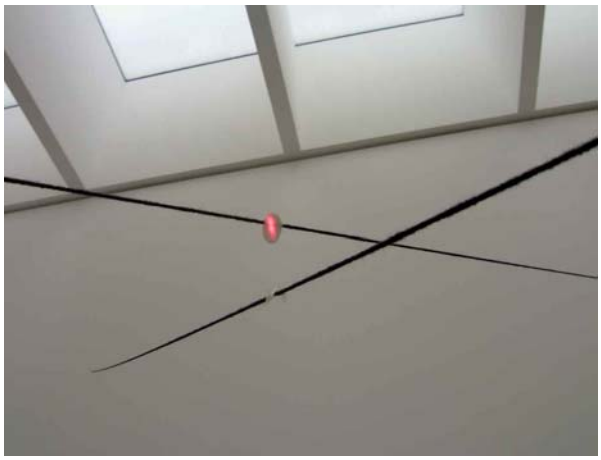


Fig. 19: Peter Weller during the measurement with the tachymeter.
Fig. 20: Detail of two stretches of yarn crossing each other. As the infrared beam of the tachymeter (red point) could not find a sufficiently large reflection surface on the yarn, a small piece of paper was fixed to the required measuring point.

Method C: Hand measurement taking into account deformations[19]
In contrast to "simple means", hand measurement, which takes into account deformations, is a common method to measure objects and rooms. It is applied particularly in the field of *Bauforschung* (Building archeology). This system of measurement is regarded as object-neutral as it makes use of a stretched-out measuring net (which can be cords spanning the walls) which initially has no relation to the room or object(s) in it. It is from this measuring net that the required points of the room and object(s) are then measured. This is done by using chain and gauge measurements and in the case of longer distances through triangular measurements. The tools include a tape measure and plumb bob (Fig. 21). This method was

[19] All the information in this paragraph is thanks to Alexandra Czarnecki.

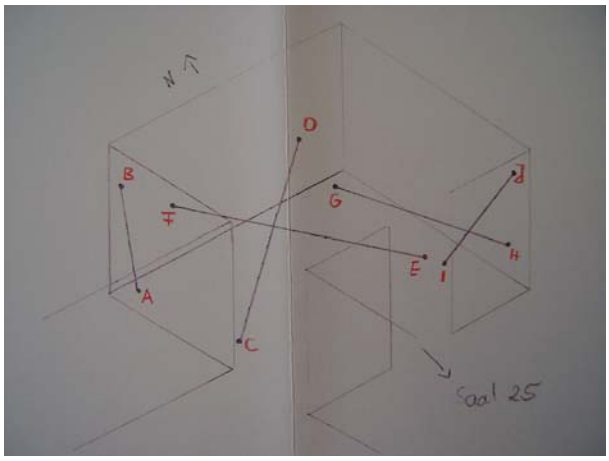
applied in order to measure all the required points of 'Untitled (Mikado)' and the exhibition room. Anchor points on the walls were plumbed to the floor as in Method A and measured from there. The measuring net, the registered measurements and lines were immediately marked on the spot with pencil on cardboard to avoid any subsequent transmission errors. And so the plan grew in size parallel to the progress of the measuring process (Fig. 22).

Fig 21: Equipment used for hand measurement taking account of deformations.
Fig 22: Drawing up the plan on site.

Documents

Method A

The results of the surveying with "simple means" were recorded on hand-drawn sketches on paper by Stephanie Thielen: There is an overview with the designations of the ten anchor points from A to J (Fig. 23) and a projection of the room, with the measurements drawn in (Fig. 24).



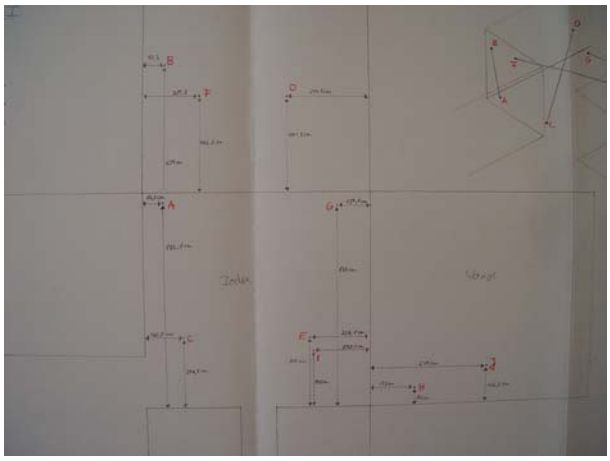
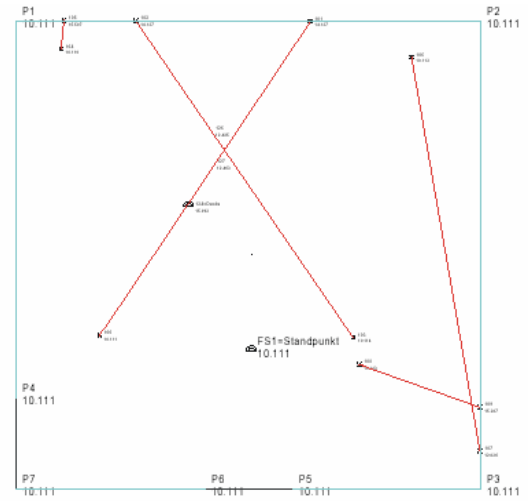


Fig. 23: Overview.
Fig. 24: Projection with measurements.

Method B

The documents Peter Weller produced consist of a layout plan (Fig. 25), four isometric views from various directions (Fig. 26) and a list of the measured point coordinates and yarn lengths.



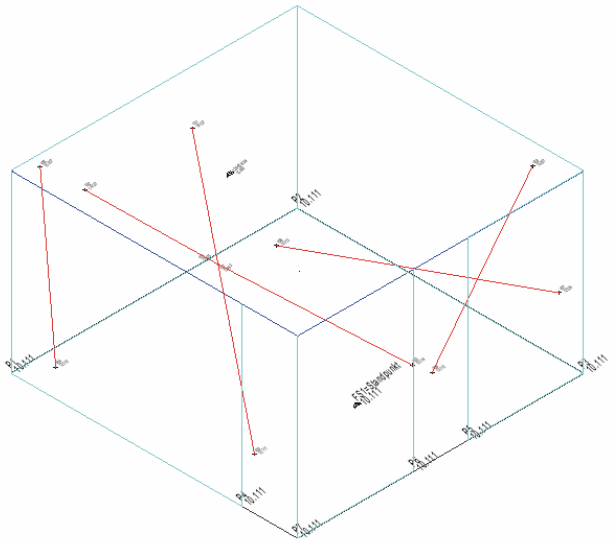


Fig. 25: Layout plan. The acrylic yarn is shown as red lines.
Fig. 26: Isometric view from the south-west.

Method C

During the measuring process Alexandra Czarnecki completed a hand-drawn plan on a scale of 1:25. It consists of a floor plan with the recorded floor points and two elevation plans of those walls that have anchor points (Fig. 27).

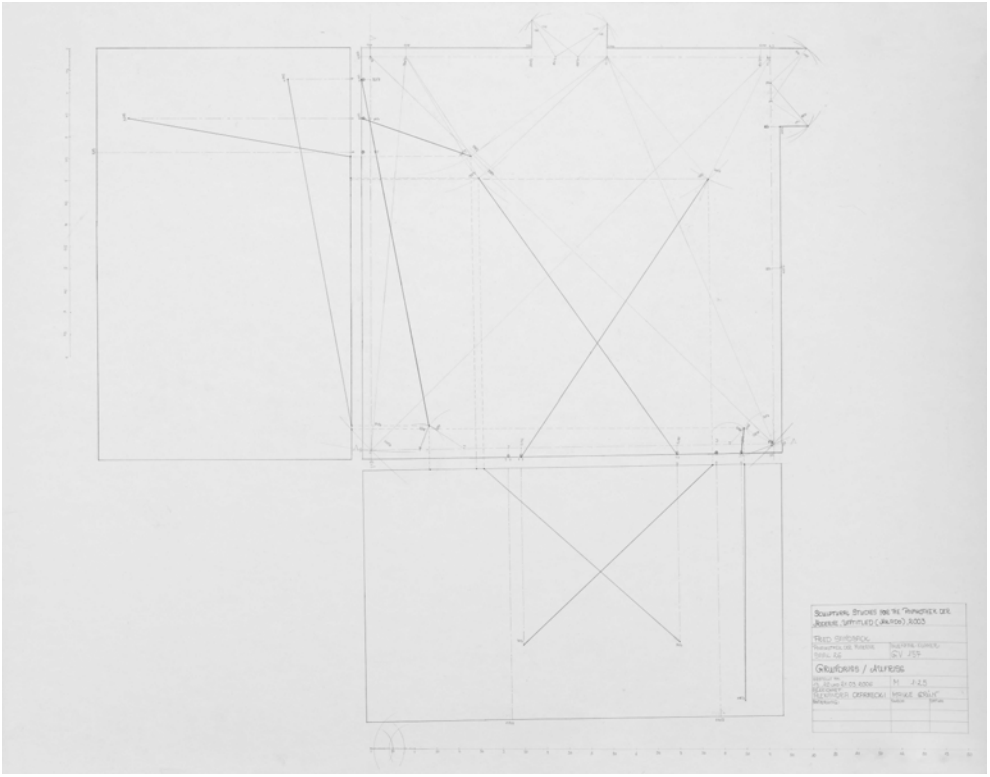


Fig. 27: Floor plan and elevation plan. Details of the lengths have been entered on to the plan.

Evaluation

Method A can be seen to have the advantage that it did not incur costs for external services. However, among the disadvantages was the amount of time spent by the participating conservators, who were not trained surveyors. First they had to work out the method of surveying they were going to apply and test it. The working time of all participants, including the drawing of the plans, came to ten hours. It is doubtful that the results are accurate because instead of one super-ordinate zero point to which all dimensions are referenced, there are several zero points, namely all four corners of the floor. Although this is less problematic if the installation is reassembled in the same place, it could lead to significant inaccuracies if reinstalled elsewhere.

Peter Weller's survey (Method B) is referenced to one superordinate zero point, as is generally the case for a geodetic survey. The survey itself took one hour, including setting up and dismantling the equipment. Subsequent processing required a further hour. Peter Weller carried out all the work by himself.[20]

Method C also has one super-ordinate zero point. Provided the work is carried out carefully, it is known for its high degree of accuracy. But, again, the method is relatively labour- and time-intensive. Two conservators each spent a whole day learning how to apply it and undertaking the measuring. Furthermore, it demands a high level of concentration, as it is all too easy for errors to creep into the measuring and drawing.

[20] For measuring 'Das Ende des 20. Jahrhundert' two people were needed: one was the operator who worked the tachymeter while the other person held the reflector mirror at the point being measured. Now that Peter Weller works with a more recent tachymeter model, the second person is no longer required.

2.4 Mark Manders 'Silent Factory', 2002: Laser Scanning[21]

Date of measurement: October 2003
Carried out by: Technical University Munich, Chair of Geodesy, Univ.-Prof. Dr.-Ing. habil. Thomas Wunderlich, represented by his assistant Dipl.-Ing. Thomas Weber and Dipl.-Ing. Thomas Schäfer

Artwork

'Silent Factory' (Fig. 28) by the Dutch artist Mark Manders (born 1968) is part of the monumental and on-going project "Self Portrait as a Building". The artist has been working on it for many years now. It consists of two towering factory chimneys juxtaposed to each other and overlooked by a nearby loudspeaker-like structure. They are mounted on wooden tabletops supported by numerous metal trestles. In addition to an armchair and two upright chairs, on which a stuffed cat is lying, there is a collection of various objects arranged on the floor. These include a watering can, teabags, sugar cubes covered with paint, pots and shoes. "Who could have designed this strange factory? An inventor? A poet? A child? The slightly reduced scale of individual elements creates a distance between the world and the viewer. The work conveys the impression almost of a photograph that brings 'to life' the portrayed objects only in our imagination. At the same time, it relates to the experience of dream in which the colour or dimension of objects and rooms is similarly changed, yet appears no less real as a result."[22]

Fig. 28: 'Silent Factory' on view at the Pinakothek der Moderne, 2003

'Silent Factory' is composed of 126 different objects and was arranged over an area of some 12 square metres.

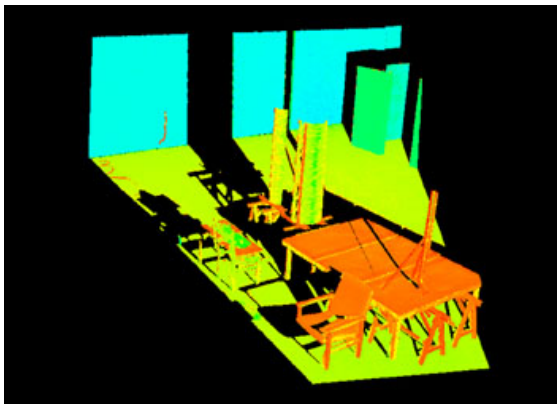
[21] Similar to a tachymeter, a 3-D laser scanner registers point coordinates on the surfaces of the objects by measuring horizontal and vertical angles as well as distances. In contrast to tachymetry, this measurement occurs automatically and randomly. This way, so-called point clouds are created that reproduce the surface of the measured object. The relevant points from this high number of measuring points are determined through editing on the computer so that they can then be further processed to create the plans.
[22] Bernhart Schwenk, Mark Manders. Silent Factory, in: PIN. Catalogue, ed. PIN. Freunde der Pinakothek der Moderne e. V., Munich 2004, no page reference (loose leaf).

Measurement[23]

Aim of the measurement was to produce floor plans and elevation plans that were as accurate as possible. The Doerner Institut had drawn up an inventory list of the artwork in which every single item of 'Silent Factory' was recorded. The individual inventory numbers needed to be integrated into the plans.

Fig. 29: The laser scanner, here on a tripod, was set up in ten different positions around the artwork.

A laser scanner was used for the surveying work (Fig. 29). The instrument used was a camera scanner[24] that scans within a rectangular field of view. This meant that recording was required from different perspectives. For this, white pass-balls were positioned at the appropriate vantage points (see Fig. 29: where one of these pass-balls can be seen in front of the scanner). For 'Silent Factory' a total of ten recordings were needed (Fig. 30). That involved setting up the scanner in ten different positions around the installation. In addition to this, different control measurements were taken by means of a foot rule. The individual scanner images were then combined within a unified system of coordinates to check that they coincided with the images of the same pass balls. As a result, there emerged a three-dimensional point cloud that modelled the outer skin of the installation (Fig. 31).



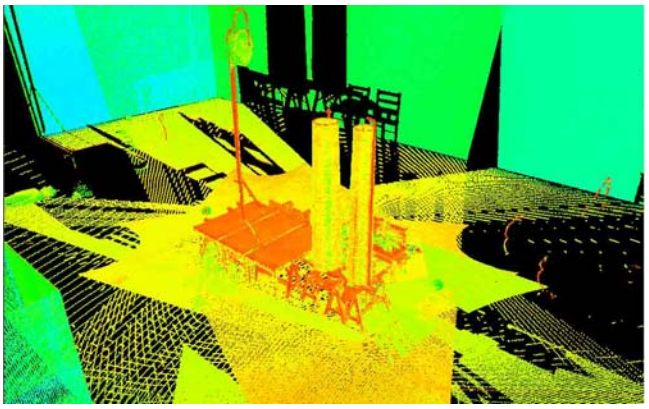


Fig. 30: One of the ten recordings. The objects are shown in false colours that represent the different intensities of the reflected laser beam.
Fig. 31: The three-dimensional point cloud. Every single point of the point cloud is backed with measuring data.

[23] Information on measuring and drawing up plans from: Thomas Weber, 3D-Vermessung und Planerstellung der Rauminstallation ‚Silent Factory' von Mark Manders, 19th November 2003.
[24] Cyrax 2500, Leica. This piece of equipment is a terrestrial mid-range scanner: i.e. it has contact with the ground by means of a tripod. It has a range of at least 1.5 m and a maximum of 100 m and a definition range of up to 1mm.

Documents

A special programme (CloudWorx) made this point cloud compatible with CAD software. It was used to construct a layout plan on a scale 1:100, a floor plan (Fig. 32; 33) and various views on a scale of 1:10 (Fig. 34). The inventory numbers of the individual objects were integrated into the plans (Fig. 33). The object's coordinates were also included on an Excel-Table. These coordinates provided key data on each of the objects in the installation – data that could be of the greatest importance if and when it were to be set up again. The coordinates were designated via the inventory numbers registered in the floor plan.

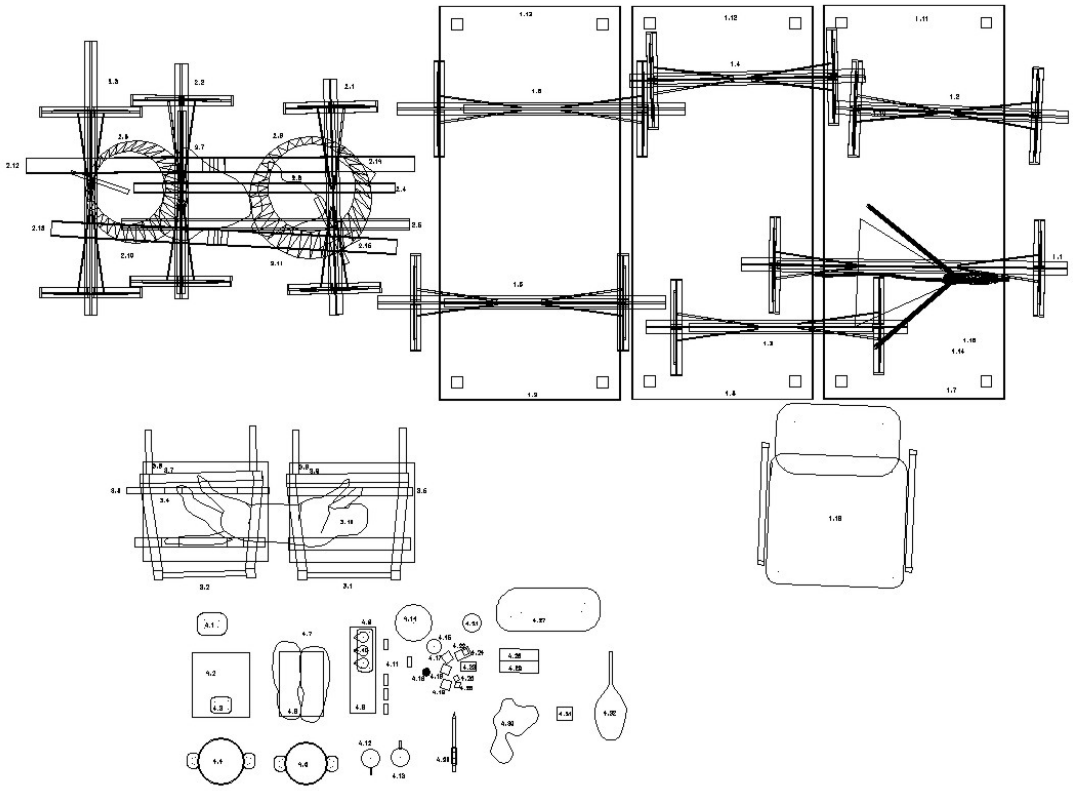


Fig. 32: Floor plan

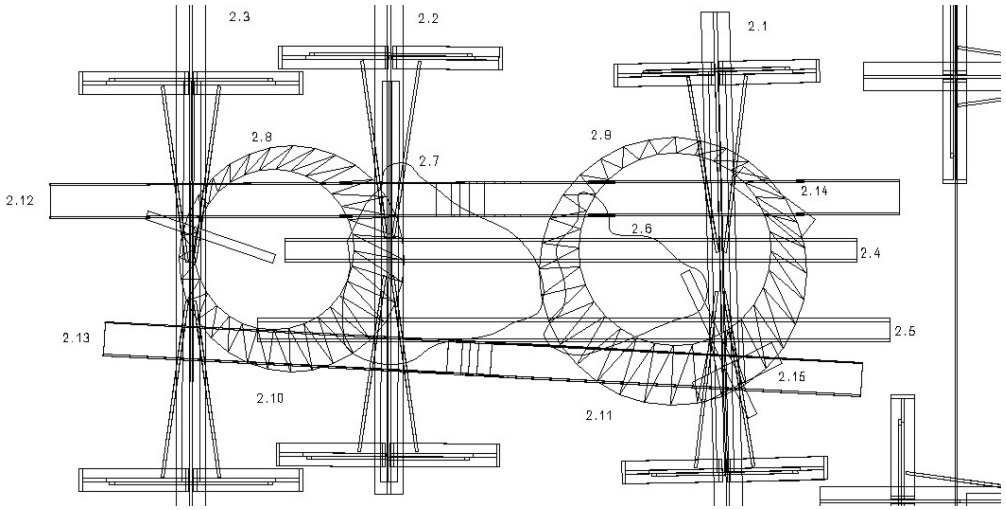


Fig. 33: Detail of the floor plan. The numbers of the inventory list are integrated.

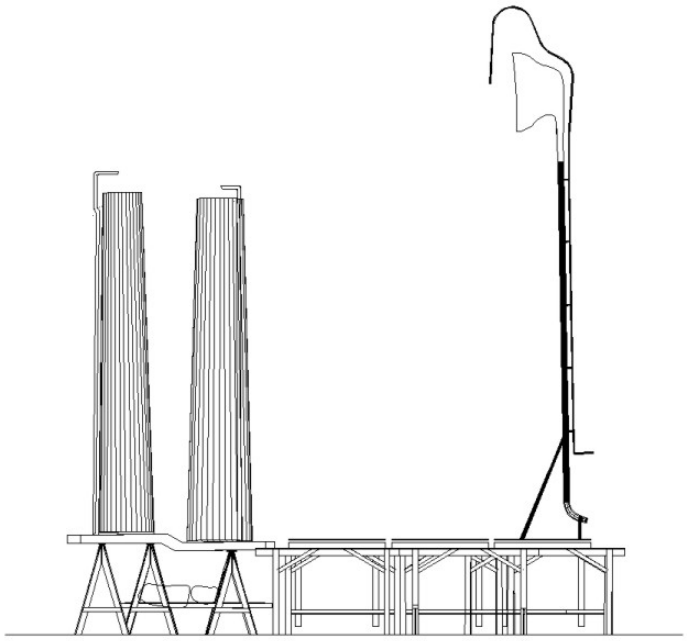


Fig. 34: One of the views.

As well as the above-mentioned data, the CD-ROM includes the point clouds that can be viewed from all sides on the computer with the aid of a free viewer made by the firm Cyclone.

Evaluation

A noteworthy feature of the 3D scanner is the fact that the actual recording of the data – that is the scanning and abstraction of the control measurements – required very little time. Only four hours were needed. However, the subsequent editing necessary to draw up the plans on the computer proved to be all the more time-consuming. This took the experts some 24 working hours all in all.[25] The plans are highly illustrative. The position of the stuffed cat or the shape of the "loudspeaker", for instance, can be made out very clearly.

Mark Manders himself spoke very highly of the measuring of 'Silent Factory': Even he would use the plans that he received as a basis for setting up a new installation. He commented that 'Silent Factory' was perfect for him in the current form of presentation and could be installed using the plans available without him being present.[26]

[25] Information kindly given by Thomas Weber to Christina Spaarschuh on the telephone on 19th July 2005.
[26] Mark Manders in a conversation with Maike Grün on 6th March 2004 in Munich.

2.5 Thomas Hirschhorn 'Doppelgarage' ('Double Garage'), 2002: Combination of tachymetry, laser scanning and digital photogrammetry[27]

Date of measurement: March 2005 and February 2006
Carried out by: Technical University Munich, Chair of Geodesy, Univ.-Prof. Dr.-Ing. habil. Thomas Wunderlich, represented by his assistants Dipl.-Ing. Thomas Weber und Dipl.-Ing. Thomas Schäfer

Artwork

In 'Doppelgarage' (Fig. 35; 36) the Swiss artist Thomas Hirschhorn (born 1957) fitted two walk-in units over an area of approximately 120 square metres with PVC flooring, cardboard wall covering with text sheets, neon lamps and numerous self-made large scale objects or mundane household utensils such as tools and working gloves. Attached to everything are cut out photos from news magazine reports on international warfare surrounding the events of September 11th, 2001. "The events of that day are a part of a complex story with numerous, partly overlapping strands of plot; the consequences of which are today still not foreseeable. The piece offers itself for reflection on this historical moment - without any dogmatism, without claims to validity and from a deeply personal perspective."[28]

Fig. 35: 'Doppelgarage' on view at the Pinakothek der Moderne, 2005. Front room.
Fig. 36: 'Doppelgarage' on view at the Pinakothek der Moderne, 2005. Back room.

The artwork is composed of almost 400 single objects. 'Doppelgarage' was first shown at the Berlin gallery of Arndt & Partner in 2002. The room arrangements there were reconstructed using temporary settings for subsequent setting up of the installation in Frankfurt and at the Pinakothek der Moderne.

[27] For technical reasons, Peter Weller planned the testing of a spherical camera. However, because of the numerous "shadows" cast by the installed objects, it was deemed to be impractical and too complex. Another reason was the fact that the spherical camera still lacks the degree of accuracy required for geodetic purposes (information kindly given by Peter Weller to Maike Grün in answer to a telephone enquiry on 19th March 2007).
[28] Bernhart Schwenk, Thomas Hirschhorn. Doppelgarage, in: http://www.inside-installations.org/artworks/artwork.php?r_id=215 (17th March 2007).

Measurement[29]

The geodetic measurement had three aims: The first was to document precisely the arrangement of the objects in the room. The numbers recorded by the Doerner Institut on the inventory table needed to be entered onto the plans. The second objective was to draw up true-to-scale plans of the walls in order to be able to fill in details such as the position of the individual card board wall coverings or the path of the electricity cables. A further aim was measurement of the temporary construction in which 'Doppelgarage' had been placed in Munich. This measuring was to be undertaken after dismantling had been completed. The purpose of this was to provide the carpenters with concrete facts and figures when setting it up again in the future.

Owing to the many different tasks, complex arrangement and geometries of 'Doppelgarage', a combination of laser scanning, photogrammetry and tachymetry were applied.

First, the laser scanner (Cyrax 2500) was used to take 15 recordings of 'Doppelgarage' from different angles. (Fig. 37) Here, careful attention was paid to ensure that the laser scanned all the objects. To incorporate the individual scanner recordings later into a uniform system of reference coordinates, the measurement surveyors spread out seven pass balls and eleven pass marks among the artwork. They also measured the latter with the aid of a tachymeter and then used these registered points to install a super-coordinate system that could integrate all of the gathered measuring points.

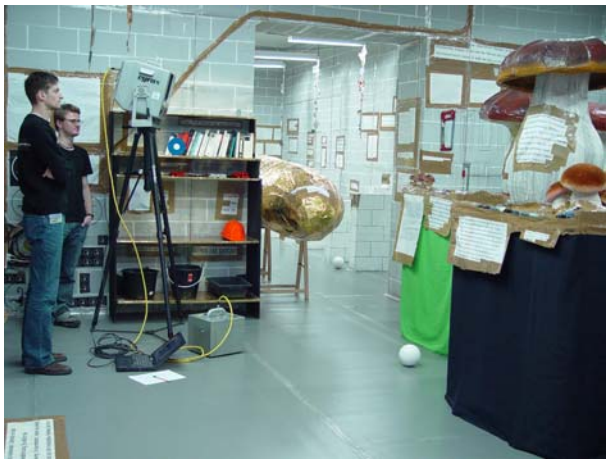
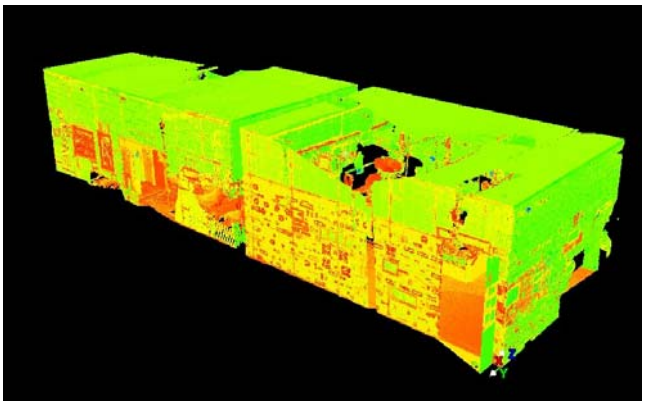


Fig. 37: Measuring with the laser scanner.
Fig. 38: Tachymetric measurement for the photogrammetric equalisation of the images.

[29] Information on measuring and drawing up plans taken from: Thomas Weber, 3D-Vermessung und Planerstellung der Rauminstallation ‚Doppelgarage' von Thomas Hirschhorn (undated). Submitted with the measuring documentation to the Doerner Institut in February 2007.

In the data processing that followed later, the scanner software Cyclone (Version 5.5 SP1) joined up the individual scans to form a point cloud (Fig. 39; 40). The programme CloudWorx was used to make the point cloud available to the CAD software with which the plans could be generated.



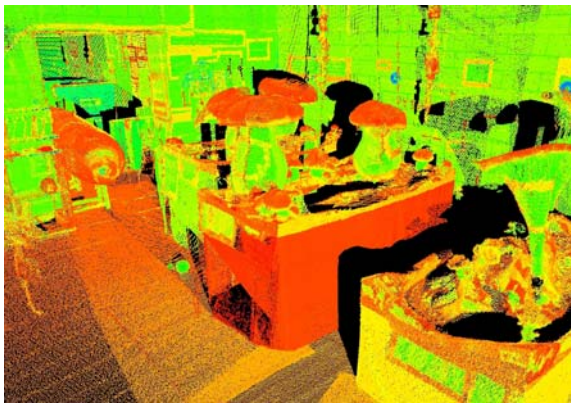


Fig. 39; 40: Views of the entire point cloud.

The documentation of the walls was carried out using photogrammetric methods. As some of the objects assembled in 'Doppelgarage' obstructed the view, this work had to be done during the dismantling stage of 'Doppelgarage' after all the objects had been removed. With the aid of a standard digital camera[30] the surveyors took several photographs of each wall, making sure every time to keep the same distance between the camera and wall. Following the print-out of these partial shots of the wall, they defined on them a minimum of four pass points – for instance on the i-points of the texts attached to the artwork – and recorded them with the tachymeter (Fig. 38). The registered coordinates were then edited to coincide with the corresponding pixels on the digital photo. A special kind of software (Eddi-2d) was applied to equalise the individual photos. After the photos showing the different parts of the wall were joined up, it was possible to complete the geometrically referenced images of the individual wall surfaces (Fig. 43).

At the third measuring session, after all the objects belonging to the artwork had been removed, the temporary construction was measured. Thomas Weber recorded all the necessary measurements with a laser distance-meter and foot rule and then drew up the plans with the aid of CAD software.

[30] Canon EOS 300d.

Documents

The Doerner Institut has seven plans on different scales at its disposal: An overview plan on a scale of 1:100 shows the layout of the installation within the setting of the entire exhibition room. A detailed floor plan on a scale of 1:25 shows the position of the objects in 'Doppelgarage'.

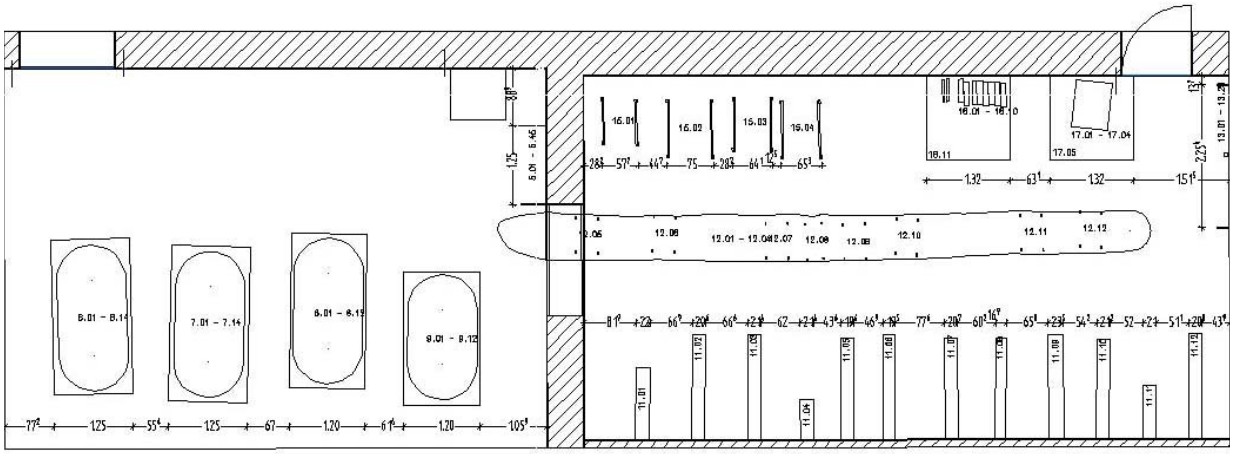


Fig. 41: Layout plan.

For two shelves and their content, separate floor plans and elevation plans were drawn up on a scale of 1:10. The inventory numbers of the individual objects are reproduced on the plans (Fig. 42).

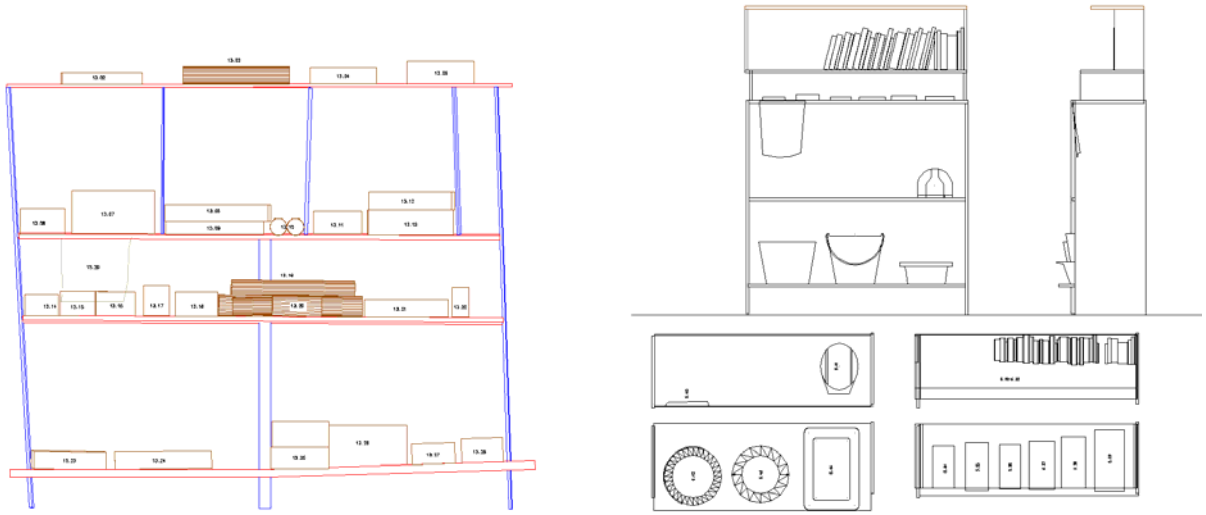


Fig. 42: Floor and elevation plans for the shelves.

The walls of 'Doppelgarage' are represented on a total of eight illustrated plans on a scale of 1:10 (Fig. 43).

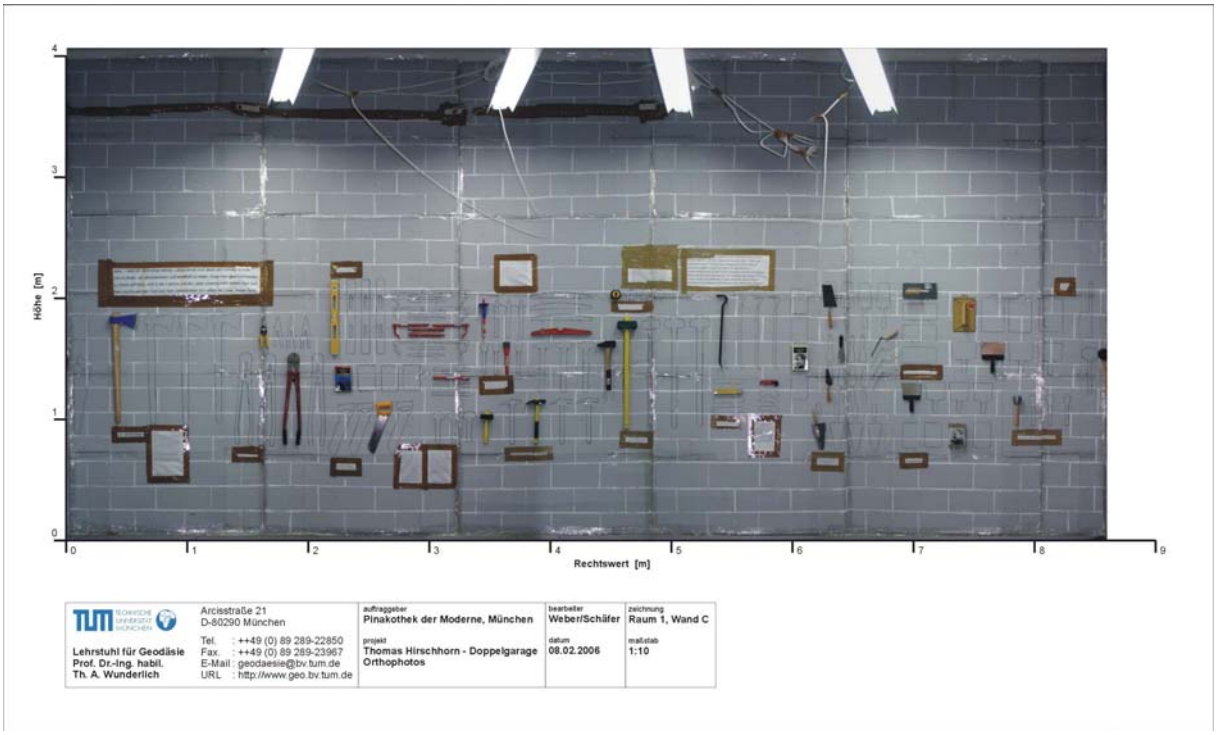


Fig. 43: Plan of equalised images, true-to-scale, of Wall 3 (Room 1) of 'Doppelgarage'. Attached to the wall are a number of work tools, whose positions are documented on this plan. The neon lights have not been equalised, as they are not on the reference level to which equalisation applies.

The temporary constructions are documented by a floor plan and elevation plan (on a scale of 1:100). Both include measurement details (Fig. 44).

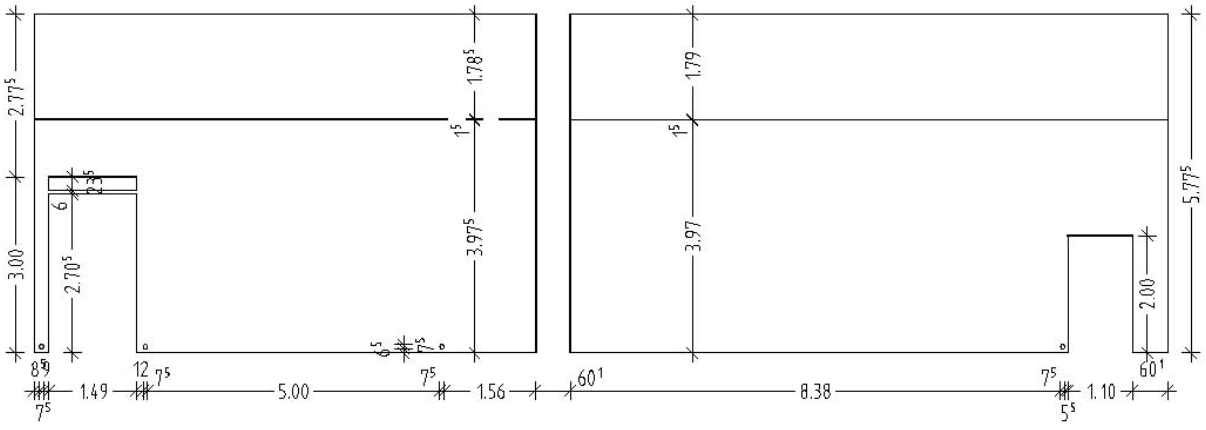


Fig. 44: Elevation plan of the temporary construction.

The Doerner Institut also received a DVD with all the data of the plans provided by analogue means. Included on this is the point cloud of 'Doppelgarage' based on the programme Cyclone 5.5, with which the point cloud can be viewed.

Evaluation

This variety of plans meant that all the requirements of the Doerner Institut could be met in a structured manner. Given the tight schedule for dismantling the installation, it was a great advantage to have the equalised photos of the walls available after only two days and to be able to undertake on them the positioning and labelling of the individual wall elements: This form of inventory-taking had to take place during the dismantling stage, since the boundaries of the individual wall parts were not recognisable in their installed state.

Thomas Hirschhorn has kept an open mind on the geodetic measurement of 'Doppelgarage'.

> „[...] für mich gilt grundsätzlich, dass alle technischen mittel benützt werden sollten um einen präzisen, effizienten, materialgerechten und zeitsparenden wiederaufbau der ‚Dopplegarage' zu ermöglichen, für mich ist nur das fremd, was den geist meiner arbeit verändern würde, die vermessung meiner arbeit kann nützlich sein, es geht aber nicht um millimetergenauigkeit sondern um die präzise umsetzung einer künstlerischen absicht, ich stelle also dem begriff der ‚genauigkeit' den begriff der ‚präzision' entgegen [...]."[31]
> ("[...] I am basically in favour of employing all technical means to facilitate a precise, efficient, material-true and time-saving reinstallation of ‚Dopplegarage'. For me, the only alien aspect would be something that changes the spirit of my work. Measuring my work can prove useful. However, it is not about accuracy to the very last millimetre but rather the precise realisation of what the artist intends. That is why I deliberately use the term ‚precision' as opposed to the concept of ‚accuracy' [...].")

At another point he writes:

> „im besitz von plänen zu sein, die einen wiederaufbau der ‚Doppelgarage' erleichtern, ist sehr wichtig, ich erhoffe mir dadurch einen komplexfreien umgang mit meiner arbeit einerseits und ich erhoffe mir auch andererseits, dass die ‚Doppelgarage' deshalb öfters ausgestellt werden kann." [32]
> ("To possess plans that make it easier to set up a reinstallation of 'Doppelgarage' is very important. On the one hand, I hope this makes dealing with my work complex-free. And on the other, I only hope it means that 'Doppelgarage' can be shown more often".)

He also remarks:

> „[...] durch ihr konservatorisches engagement im museum aber – denke ich – ist es nun möglich den wiederaufbau meiner arbeit nicht als riesen-belastung oder schwerst-arbeit sondern als eine normale, machbare aufgabe für die institution zu sehen, eine genaue kopie zu machen hilft dabei jedoch nicht, für mich müssen vielmehr geringfügige änderungen der ‚Doppelgarage' (wie schon besprochen: zugang, notausgang, länge der räume) möglich bleiben, je nach den räumlichkeiten des (neuen) ausstellungsortes gilt es auch hier der künstlerischen mission der arbeit treu zu bleiben". [33]
> („[...] Thanks to the commitment of your museum conservators, it is now possible – I think – to regard the reinstallation of my work not as a huge burden or hard work but as a normal, feasible task for the institution. However, it is not helpful to produce an exact

[31] Thomas Hirschhorn's written reply to a questionnaire of Christina Spaarschuh and Maike Grün, reply mailed on 28th August 2005.
[32] Ibid.
[33] Ibid.

> copy. I would rather see changes to ‚Doppelgarage' continue to be possible (as already discussed, access, emergency exit, length of the rooms). Allowing for the particular spatial features of the (new) location for the exhibition, what really counts here is staying faithful to the artistic mission of the work.")

In summary, it can be said that Thomas Hirschhorn endorses the use of plans for reinstallation for reasons of efficiency and time saving. However, he does not wish to see them as binding. Rather, he thinks it important to be able to undertake minor changes that facilitate showing the installation at different locations.

2.6 Olaf Metzel 'Reise nach Jerusalem' ('Musical Chairs'), 2002: Combination of tachymetry and digital photogrammetry

Date of measurement: September/October 2006
Carried out by: Weller Vermessung, Dipl. Ing. Peter Weller, Waltenhofen

Artwork

'Reise nach Jerusalem' ('Musical Chairs') (Fig. 45) by the German sculptor Olaf Metzel (born 1952) is an almost seven metre-tall sculpture commanding the space around it. It was commissioned directly by the Pinakothek der Moderne to mark the opening of the museum. For the giant staircase leading up from the central area of the Rotunda to the first floor, Olaf Metzel created a swirling, tower-like structure consisting of hundreds of multi-coloured and partially distorted Plexiglas strips resembling lamella. Stacked up inside the structure are plastic chairs that are melted together to form likewise distorted shapes. "In Olaf Metzel's work the distorted and damaged are a constant feature. Whenever the rule of order is disrupted, the sculptor is in his element. The basis for this destruction and deformation is the expectation of a visual ideal, of the predictable. It is this that he targets in order to create a different ideal of beauty. [...] The stack of melted, mangled chairs in 'Musical Chairs' is to be understood as a metaphor that can be applied to political systems and social situations, structures and mechanisms. Who owns a chair? To whom will one be allocated – and who will still have one tomorrow? Who is allowed to take a seat and who may remain seated?"[34]

Fig. 45: 'Reise nach Jerusalem' at the Pinakothek der Moderne, 2002. View from the landing down the stairway into the Rotunda.

Measurement

'Reise nach Jerusalem' was dismantled in the autumn of 2006. Aim of the measurement was to establish the exact stationary point of the supporting aluminium structure and the positions of the stacked up chairs. A further objective was to produce equalised photos on which the position, fixture, flow and numbering of the individual Plexiglas strips could be recorded during dismantling. A high degree of accuracy was called for in the documentation process since the distortions of the lamella strips were adapted exactly to the architectural features of the ceiling and staircase. Even minor deviations during future reinstallation could result in unfavourable stress and strain on the Plexiglas parts.

[34] Bernhart Schwenk, Destruction and Décor, in: Olaf Metzel. Musical Chairs, ed. Bayerische Staatsgemäldesammlungen, Pinakothek der Moderne, München, Verlag Silke Schreiber, Munich 2003, pp.58-59.

The measuring was done in several steps. First, a tachymeter was used to measure the spatial characteristics – i.e. the area around the installation, together with the staircase, walls and ceiling (Fig. 46). During the second step three measuring points were attached to each of the colour lengths of Plexiglas strips and then likewise measured with the aid of the tachymeter. From the measured three points [...] per length and the distance in height from the base point of the installation to the top (the ceiling) a rectangular length was then calculated on which the digitally photographed (Fig. 47) [35] colour length could be equalised to scale [36] and printed out. These equalised photos were used both before and during the dismantling stage to document the Plexiglas lamella strips. After the lamella strips had been removed, Peter Weller returned with the tachymeter to measure the reference points of the chairs and the aluminium support structure (Fig. 48; 49).

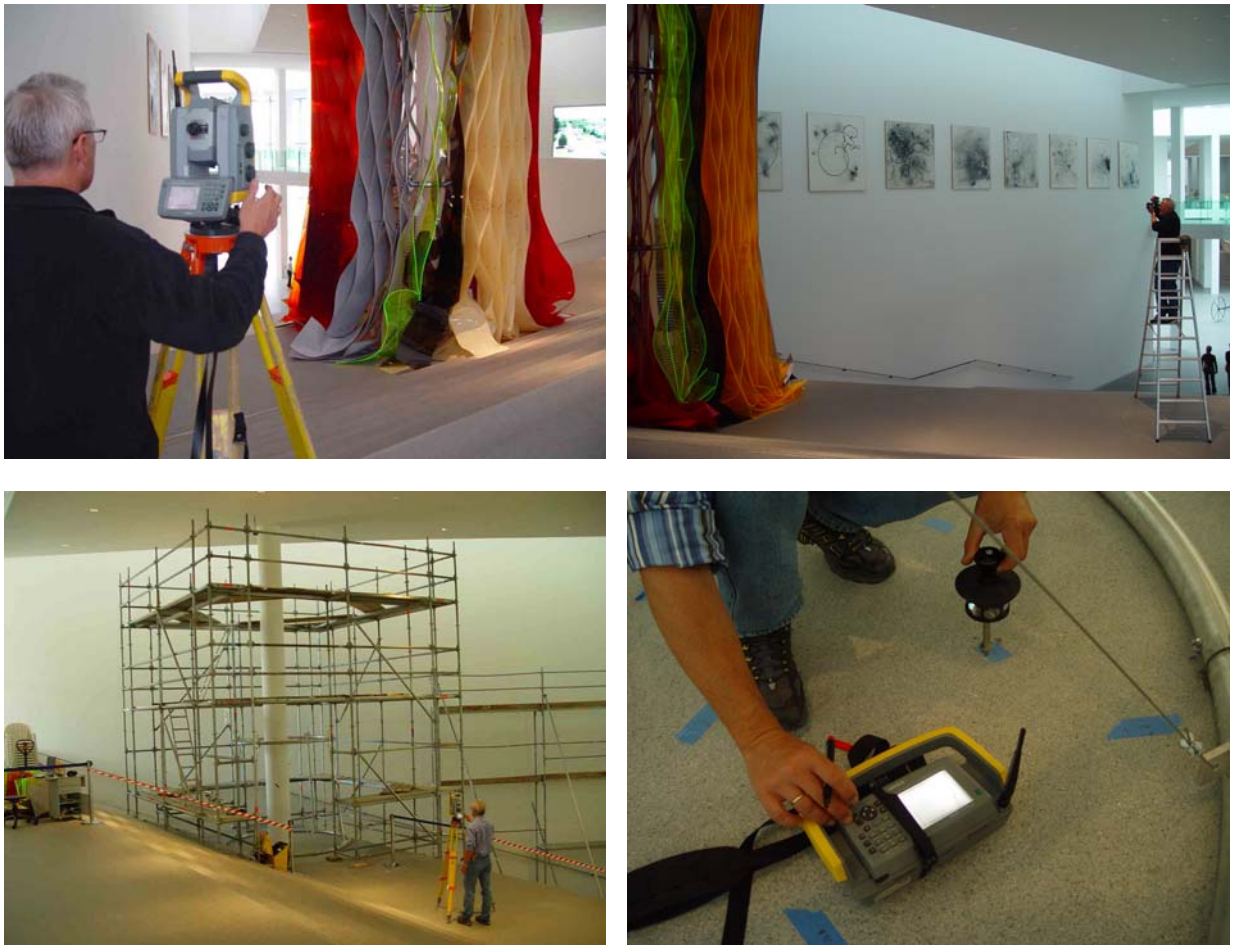


Fig. 46: Tachymetric measurement of the measuring points on the colour lengths.
Fig. 47: Taking photographs with the measuring camera.
Fig. 48: Tachymetric measurement of the floor points of the aluminium support structure and the chairs (the scaffolding has not yet been taken down).
Fig. 49: Peter Weller is holding the reflector (reflecting prism) at a floor point with his left hand. The tachymeter finds the reflector automatically. This means that just one person is needed to undertake the measuring.

[35] Sony R1 Cyber shot with a calibrated objective.
[36] Computer software Elcovision 10, produced by PMS, Switzerland.

Documents

The measuring points registered by the tachymeter were drawn with the aid of the CAD Programm autoCAD 2004 and printed out on paper on a scale of 1:50 and 1:25 (Fig. 50). These formed the layout plans that showed the architectural features such as the staircase, the layout of the aluminium support structure and the floor points of the chairs. On a further plan the positions of the differently colour strips of the Plexiglas lamella were recorded. Peter Weller then printed out the illustrated plans with the equalised photos (Fig. 51) to the scale of 1:10. All this data, including a written description of how to proceed, was submitted to us in the additional form of a CD.

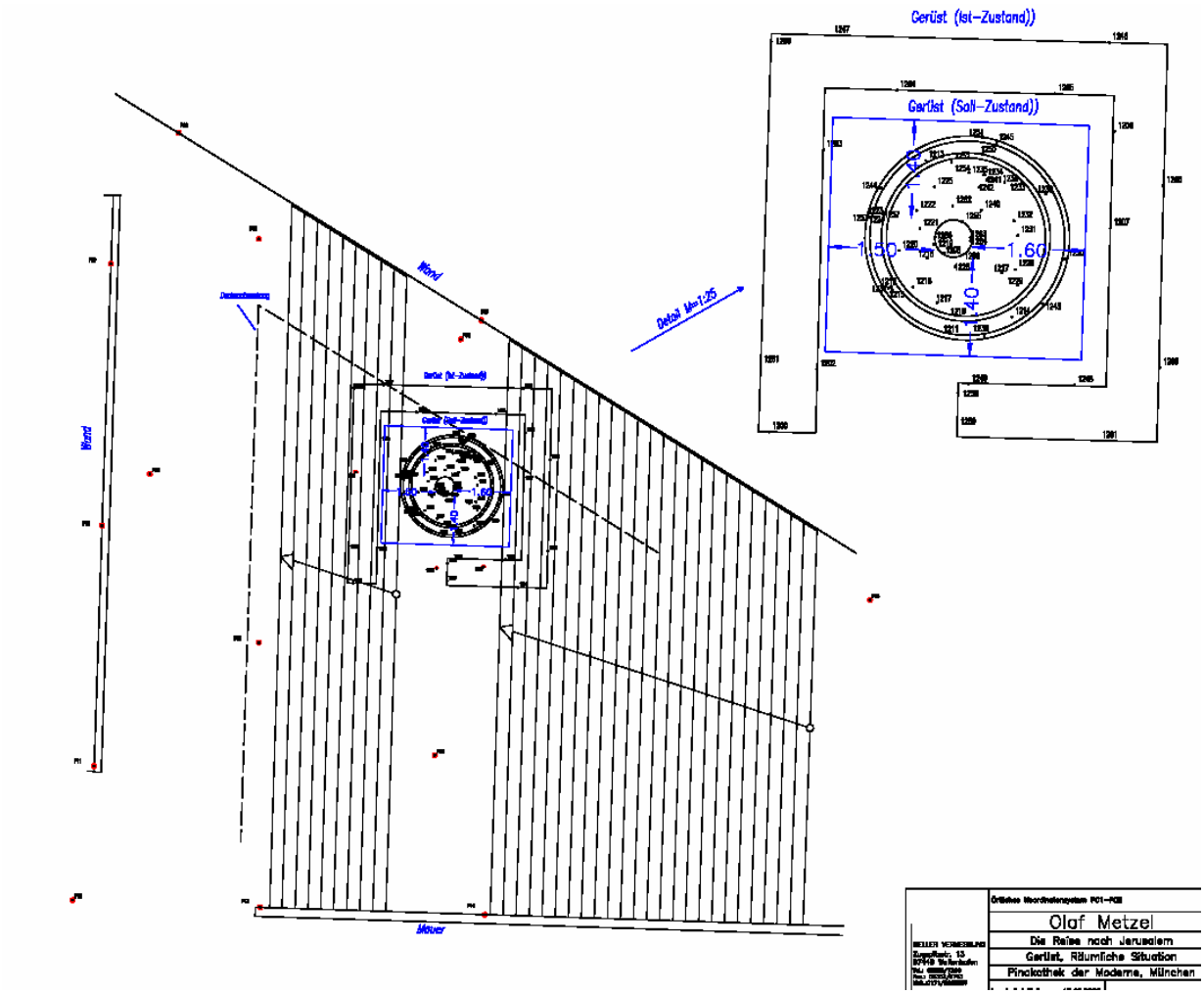


Fig. 50: Layout plan of 'Reise nach Jerusalem' stairway. The open square around the circular support structure represents the measurements of the scaffolding as they actually were during dismantling. Since in future it is intended to position it nearer to the sculpture to make setting up and dismantling easier, the desired measurements are indicated in blue.

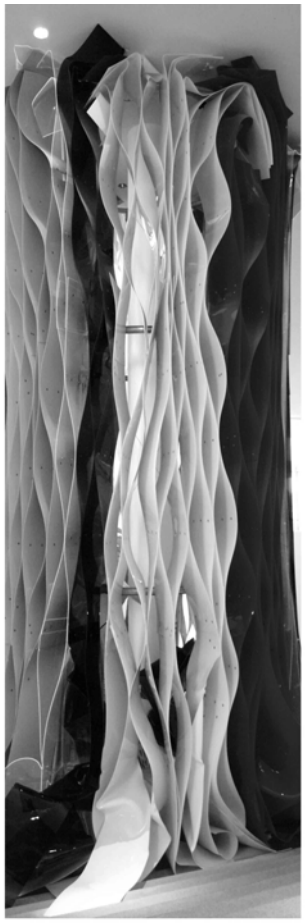


Fig. 51: Plan of an equalised photo showing the individual lamella strips of colour length number 1 (ivory coloured).

Evaluation

All participants judged the chosen method to be expedient and effective. As far as future reinstallations are concerned, Olaf Metzel makes it quite clear that 'Reise nach Jerusalem' should be reinstalled exactly as it was. He conceived it especially for this location. In his view, the way it was is perfect. He warmly welcomes the drawing up of documentation that is as exact as possible to facilitate a reinstallation true to the original.[37] This being so, the plans will serve as an exemplary model for any future reinstallation.

[37] Olaf Metzel in conversation with Bernhart Schwenk, Susanne Willisch and Maike Grün on 8th August 2006 at the Pinakothek der Moderne, Munich.

3 Comparison of the methods of measurement

The technique of surveying with the aid of a tachymeter proved to be very practicable on all counts. The time required for surveying and editing was well within reasonable limits. This method creates accurate and clearly arranged plans.

In the case of 'Das Ende des 20. Jahrhunderts' the method using the tachymeter was the best solution under the given circumstances. In just a short space of time the dismantling team was able to record the measured data with a high degree of accuracy and make available it to the reinstallation team very quickly. Parallel dismantling and reinstallation would not have been possible with a laser scanner because the time required to process the measured data takes relatively long. In any case, the recorded measurements would have had to be transferred to a tachymeter at some point because although the laser scanner can record the data, it cannot project it back again.

Laser scanning has the advantage that complex geometries or rounded shapes can be measured in a short space of time and thus realistically reproduced. It is easier to measure rounded or elaborate shapes this way than with a tachymeter as there is no need to target individually every single characteristic of the body. The resulting plans offer a particularly good description and show the objects very accurately in contrast to tachymetry. There is only a relatively small danger of overlooking a measuring point. The actual scanning process is not very long. Each image takes about 16 minutes, during which the scanner (Cyrax 2500, Leica) operates on its own. However, as mentioned earlier, it does require all the more time at the editing stage in order to create the plans on the computer. This is because the relatively few points that are relevant to the plan have to be extracted from an immense number of individual points in the point cloud. In the case of 'Doppelgarage' these amounted to five and a half million. Here one needs to take into account the fact that the reduction of the coordinates to a minimum is subject to the interpretation of the person editing and as a result liable to inaccuracies. Another issue is the purchase price of a laser scanner. It is very high, something that is inevitably reflected in the surveying costs. By contrast, a tachymeter is considered part of the standard equipment used by every surveyor.

In the case of Fred Sandback's work, the lengthy period of time required (Method A and C) to obtain what were partly unsatisfactory results (Method A) was an issue for discussion. Tachymetric surveying, on the other hand, again proved to be very convincing. In view of the greatly reduced number of working hours required here and the precision of the results, it is well worth asking a professional surveyor for a quotation.

Generally speaking, one can say that the degree of accuracy reached by all the applied measuring methods, assuming them to be conducted with care, is in the region of +/- 2-3 mm. Although in principle hand measurements are exact to the last millimetre they run the risk of perpetuating errors. This means that initial minor problems can build up into major inaccuracies.

A problem for all measuring equipment operating without a reflector is the fact that sometimes the emitted laser or infrared rays are reflected either incompletely or only insufficiently. This can occur, for example, on glass surfaces or fine particle elements like wires. In such cases the surveyor can overcome the problem by attaching pass marks or something similar at strategic points (see the measurement of Fred Sandback's 'Untitled (Mikado)', Method B).

In the case of illustrated plans using photogrammetry it should be noted that true-to-scale representation applies to only one level (see Fig. 26; 27). This method of measurement is thus well suited to artworks or groups of objects that are laid out on the floor and not very tall.

4 Use of the plans for reinstallation

The installations by Beuys and Sandback are the only ones so far that have been set up again with the aid of the gathered data. Whereas for the reinstallation of 'Das Ende des 20. Jahrhunderts' the basalt stones had to be arranged exactly in accordance with the specifications of the surveyor, the plans (Method A) for 'Untitled (Mikado)' served far more to trace the drill holes of the anchor points on the floor and wall and to assign the yarns correspondingly.

Generally speaking, there are two ways of using geodetic plans for a reinstallation. On the one hand – as happened in the case of 'Das Ende des 20. Jahrhunderts' – the surveyor can read all the coordinates into a tachymeter and then project them in the room in question. On the other hand – and here a surveyor is not needed to carry out the task – it can be a person with a ruler or something similar who measures the distances between the required points on the plan, converts them to scale to their actual dimensions and then transfers these to the room. It may be of help here to span cords (arranged at right-angles) to which one can refer when measuring up. This procedure could well be considered, for instance, for a reinstallation of 'Silent Factory'.

The two possibilities can, of course, be combined. This is conceivable for a true-to-plan reinstallation of 'Himalaya Goldsteins Stube': A surveyor projects into the still empty room the floor points of the larger objects such as the wallpapered walls, major pieces of furniture and the carpets. These points are marked with adhesive tape on the floor. Using these markings, it is then possible to proceed with setting up the corresponding objects. The arrangement of the remaining objects, like the laundry stand on one of the carpets or the crockery on the dining table, is determined on the plans by analogue means. The setting-up team can undertake this work without the help of a surveyor.

As a rule, photogrammetric plans can only be measured with a ruler or something similar – provided a true-to-scale print-out is available (for example 1:10). Here it should be noted that this is only possible on the level which has been equalised. In the case of the laid dining table in 'Himalaya Goldsteins Stube' it is the tabletop that is represented according to scale. This means it measurable. The objects on it, though, such as the glass bowl, have had their top parts unequalised – so measuring is not appropriate here.

5 Archiving

The surveyors gave us all the generated documents such as plans, photographs and lists, both on paper and in digital form on CD-ROMs. The digital data was in standard format such as DWG and DXF files (generated by CAD-software) or as Excel, Word and PDF documents. This data is available on the server of the Bayerische Staatsgemäldesammlungen. It is also stored on DLT (Digital Linear Tape) and LTO tapes (Linear Tape Open) for offline archiving. The hand-drawn plans as designed for Fred Sandback's 'Untitled (Mikado) were scanned. The original documents and/or copies in analogue form – on paper/cardboard - are archived like all conservation documents on paper in the documentation files of the Doerner Institut.

6 Summary and outlook

Overall, the results of the measurements hitherto undertaken at the Pinakothek der Moderne can be seen as positive. In our view, they are a fundamental form of documentation that serves to promote future appreciation of the artworks in question. As well as their generic value the plans have purely practical advantages. They offer precise details on how to set up a reinstallation – thus saving time and making the work more efficient. Together with the museum's inventory lists, which include written information on individual objects of the artwork concerning naming, measurements and approximate localisation and whose numbers are to be found on the plans, they provide a basic overview for persons unfamiliar with the work.

It is especially helpful when the surveyors produce technical reports on the measuring, drawing up of the survey plans, number and type of documents provided.

One area that has not been researched at all is the extent to which measurement damages the artworks. This applies in particular to methods that operate without the use of a reflector and result in laser or infrared rays beaming directly on to the artwork. The impact is especially concentrated during laser scanning. Does the effect of the rays lead to material changes?[38] This is a fundamental issue that needs to be addressed.

As elsewhere, technological progress has been making rapid advances in the field of measurement techniques. This has been particularly noticeable in recent years when a series of measurements were carried out at the Pinakothek der Moderne between 2002 and 2007. Whereas previously two people had to team up to measure 'Das Ende des 20. Jahrhunderts' tachymetrically, these days only one person is needed to do this work. Camera scanners like the ones used to measure 'Silent Factory' and 'Doppelgarage' have now been replaced by spherical scanners. These have a much larger field of view, thus reducing the numbers of recordings required. However, despite these technical innovations, there is still much value in applying classical methods of measurement. In some instances it takes nothing more than a tachymeter to register quickly and reliably the few points that are relevant and produce from these perfectly adequate plans. In such cases the use of a laser scanner would be a clear example of overkill. On the other hand, the scanner can perform an invaluable service in measuring highly complex geometries. Ultimately, the decision about which method of measurement is appropriate has to be taken separately for each individual artwork.

[38] Information kindly given by Frederika Huys, conservator at Stedelijk Museum voor Actuele Kunst (SMAK), Ghent, May 2006.

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