

THE LAST OF THE WORLD'S OLD ZEPPELIN HANGARS IN RIO DE JANEIRO/BRAZIL DOCUMENTATION OF AN ENGINEERING HERITAGE

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ABSTRACT

Government authorities of many developed countries are much concerned about documentation and preservation of their historical cultural heritage. In this context, international organizations (like CIPA and ICOMOS) show interest in utilization of photogrammetric techniques for the preservation of architectural heritage. This activity requires knowledge of various technologies and involves large investments in documentation and maintenance of monuments within their original characteristics.

The presented project relates to the use of non-metric digital cameras and the PhotoModeler software applied to documentation, maintenance and restoration of monuments and historical sites, low cost techniques but with high precision.

For this study a highly interesting object was chosen; the last of the world's old Zeppelin hangars, situated at Santa Cruz Airbase, close to Rio de Janeiro.

Images were taken in accordance with the requirements of PhotoModeler projects. The photogrammetric models were dimensioned with coordinates obtained by ground control. In this process, the spatial coordinates of well identified and well distributed points of the object were determined by forward intersection and trigonometric leveling, from stations of a closed traverse, located around the hangar.

After processing the images with PhotoModeler software, an orthophoto and a plot by AutoCAD software of the main façade together with a 3D-model of the object could be generated, confirmed in their dimensions, as a final product. An animation with a flying Zeppelin could be also performed.



1. INTRODUCTION

In continuation of the Institute's project "Initiation to Research", students had to prepare a study about architectural photogrammetry under supervision of their tutors. For this study a highly interesting subject was chosen:

The last of the world's old Zeppelin hangars, situated at the Santa Cruz Airbase, close to Rio de Janeiro.

The following reasons led to this selection:

- The hangar with its installations (crane carriages, elevators, stairs, motorized gateway, etc.) is already registered as a national historical monument and therefore a complete documentation could be of interest to the present owner, the Brazilian Air Force.
- This documentation could be of interest, too, to the Zeppelin Museum Friedrichshafen GmbH, Friedrichshafen/Germany, associated with the former and present Zeppelin factory, as well as to the constructor of the hangar, Gutehoffnungshütte AG., Oberhausen/Germany.

- This documentation could be also of interest to ICOMOS / UNESCO as a subject for a World Engineering Heritage.
- The study could show some examples of the so-called "As-Built-Drawings" (Documentations) according to Brazilian Standards.

2. HISTORICAL BACKGROUND

During the period of the Zeppelins a large number of supply, maintenance and reception hangars (more than 20) were constructed in many countries around the world. Regular flights between Friedrichshafen / Germany and Rio de Janeiro / Brazil started in 1931 and the construction of the hangar began in 1933. Due to the large sizes of the Zeppelins:

- LZ 127 Graf Zeppelin, 235 m length
- LZ 129 Hindenburg, 245 m length

with a maximum diameter about 40 m for both, the hangar was dimensioned to 270 m length, 60 m height and 50 m width, in order to shelter the Zeppelins.

Remarkable is the two-folded motorized gateway at the southern entrance of the hangar – about 50 m high with a weight of 80 tons each; unique in the world and still in operation ! The hangar was inaugurated in 1936 but was not used very often. Zeppelin flights were stopped by German government after the accident in May 1937 in Lakehurst / USA, when the LZ 129 Hindenburg was destroyed by fire. According to information from the Zeppelin Museum, all the hangars of this construction type were demolished and thus the hangar of Rio de Janeiro is really the only remaining testimonial of the famous Zeppelin era.(see Figure 1, References 3., 4., 6. and 11.)



Figure 1

In the present decade, a modern version of a Zeppelin for rapid transportation of big and heavy loads, the “Cargo Lifter”, started to operate and a new hangar was constructed in Briesen Brand, close to Berlin. However, for various reasons, the hangar was transformed into a tropical garden, the “Tropical Island Dome“. (see Figure 2, References 10. and 11.)



Figure 2

3. SCOPE OF THE PROJECT – PROJECT PLANNING

3.1 Definition of the Project

After the first reconnaissance of the site, the project was defined as follows:

- Manufacturing of an orthophoto and a plot of the main façade of the hangar in the rather small scale of 1:500, considering the large dimensions of the object.
- Generation of a 3D-model of the object.
- Making an animation of this 3D-model with a flying Zeppelin.

3.2 Project Planning

In this **didactic project** the students were oriented by their tutors to make use of appropriate procedures in order to obtain these above mentioned aims in an efficient way. Thus, during a further visit to the site, the following specifications were established:

3.2.1 Determination of spatial coordinates of control points:

- No use of targets, because not recommendable. Instead, pointing to well identifiable details of the construction, such as window corners, roof edges and others.
- Due to very large distances, EDM-measurements in reflector-less mode would not be possible. Instead, use of forward intersection in the x-y-plane with simultaneous trigonometric leveling in the x-z- plane, with preference from 3 traverse stations (double forward intersection).
- Number of control points within the main façade: about 15 to 20.
- Tolerance of coordinates of the control points :
 - ✓ Tolerance : ± 100 mm
 - ✓ Precision : ± 30 mm

3.2.2 Traverse: A closed traverse composed of 6 stations should be located as near as possible to the hangar, considering a large Taxi Area at one side.

The following values for tolerances/precisions for the coordinates of traverse stations were fixed:

- Tolerance : ± 30 mm
- Precision : ± 10 mm

3.2.3 Images: Digital cameras, such as:

- SONY DSC- P 92
- CANON EOS- D 60

should be made available.

Low aerial images for the generation of a 3D-model of the hangar should be taken.

3.2.4 Coordinate Systems: The choose of an adequate coordinate system for the project is very important (see 2. Benning).

Thus, a coordinate system for the modeling of the hangar, as shown in figure 3, was defined.



Figure 3

Source: IKONOS II image

The horizontal x-axis of this so-called “Object System“ is placed into the main façade of the object, as recommended in literature and experienced in several projects of IME (see 7. Löschner, 5. Erwes et al.). In the case of symmetrically constructed buildings, like the hangar, the “Object System“ is specially suited for “As- Built –Drawings” and offers considerable advantages with regard to the main façade, such as:

- points in vertical lines : x and $y = \text{constant}$
- points in horizontal lines : y and $z = \text{constant}$
- points in the same vertical plane : $y = \text{constant}$
- points in different parallel vertical planes: $\Delta y = \text{constant}$
- horizontal distances : Δx

For small plane objects a simplified ground control (using tape and level only) is sufficient.

An intermediate arbitrary local coordinate system for the initial section of the traverse and its transformation into the object system was proposed.

4. GROUND CONTROL

4.1 Traverse

The 6 stations of the traverse are well marked in order to allow further investigations to be made in the field, such as “As-Built- Drawings”.

For the traverse measurements (distances and angles) a Total Station LEICA TC 605 was used. Atmospheric corrections for measured distances were applied.

Brazilian Standards, for instance: NBR 13. 133 (see 12. ABNT Norma NBR 13. 133) require a presentation of the closing errors versus tolerances for traverses. These values are mentioned as follows: (see Figure 4)

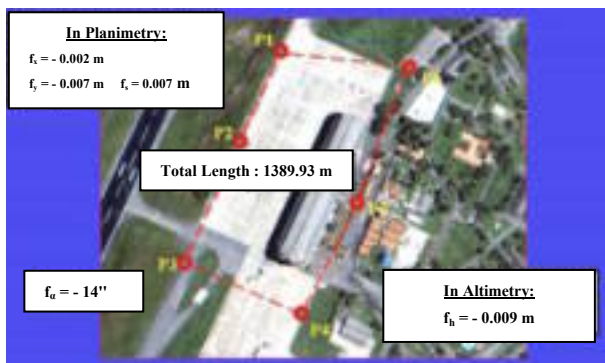


Figure 4

The obtained precisions of the traverse are well within the specified tolerances.

4.2 Transformations

The initial section of the traverse, calculated in an arbitrary local coordinate system, was transformed into the object system through a so called “Plane similarity transformation with over determination (HELMERT – Transformation) programmed by the author Walter da Silva Prado (see 1. Albertz / Kreiling, 8. Luhmann, 5. Erwes et al.). After that, all coordinates were calculated in the object system.

4.3 Control Points

The spatial coordinates of 36 control points, well distributed in the façades and on the roof of the hangar, were determined by forward intersection with simultaneous trigonometric leveling by use of LEICA TC 605 or WILD T 1000 from the traverse stations (see figure 5). The computation were programmed by the author Walter da Silva Prado. In most cases, a double forward intersection, based on 3 traverse stations, were made. (see Figure 6)

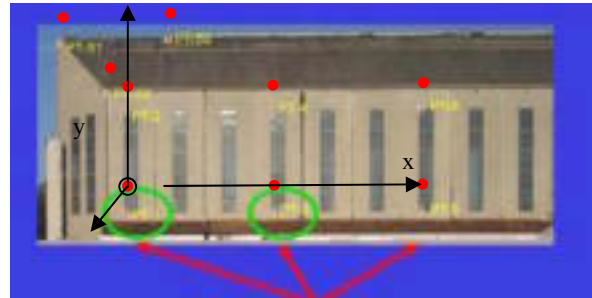


Figure 5



Figure 6

The obtained standard deviations of the coordinates, derived from double/triple determinations, are well within the established tolerances as shown below:

- $m_x = \pm 15.1 \text{ mm}$
- $m_y = \pm 22.8 \text{ mm}$
- $m_z = \pm 14.6 \text{ mm}$

Observation: the maximum distance was 367 m.

4.4 GPS – Measurements

For the used EDM (TC 605) a calibration certificate, as required by NBR 13. 133, was not available and therefore it was decided, to check the position of the traverse stations by GPS – measurements. The equipment used was:

- ASHTECH Z-12
- TOPCON LEGACY

The results were:

- Planimetric positions of traverse stations confirmed within $\pm 4 \text{ mm}$
- Scale factor of EDM versus GPS; + 2 ppm.

5. TAKING IMAGES AND CALIBRATION OF CAMERAS

In several missions about 48 images in different image scales of all 4 façades were taken with the camera SONY DSC- P 92.

Also, about 26 low aerial images of the hangar were taken with the camera CANON EOS-D 60.

Both cameras were calibrated in accordance with the procedures prescribed in the PhotoModeler User Manual. (see 9. PhotoModeler Pro)

6. PROCESSING OF IMAGES WITH PHOTOMODELER SOFTWARE

All taken images were processed by PhotoModeler software. Here will be shown 2 examples for referencing points in several images (Figures 7 and 8).

For the assembling of the 6 individual orthophotos to a mosaic, the software Aldus Photostyler was employed. The accuracy of this orthophotomosaic was checked by field measurements and served for the plot in AutoCAD. (see APPENDIX)



Figure 7



Figure 8

7. RESULTS

After processing the images with the PhotoModeler software, assembling and plotting, the following results were or will be obtained;

- An orthophotomosaic in 1:500 scale of the main façade, composed of 6 individual orthophotos.
- A plot of the main façade in 1:500 scale performed by AutoCAD software.

(see APPENDIX)

- A 3D model of the hangar (still in progress).
- An animation of this model with a flying Zeppelin. (still in progress)

8. CONCLUSIONS

The PhotoModeler software proved to be very useful in the generation of the orthophotos that formed the base for the orthophotomosaic.

This served for the plot performed by AutoCAD software. The obtained accuracy of both products meets the requirements of Projects for Documentation of Monuments and Architectonical and Archeological Sites.

For small plane objects (façades, walls, etc.) a simplified ground control - using tape and level only - is sufficient for the orthophoto generation. In case of large objects, however, the ground control has to include topographic measurements, the employment of theodolites or total stations is a must.

This project showed the PhotoModeler software has good potential for use in the restoration and maintenance of historical monuments, using low cost technology.

Speed, capacity to store a large volume of data in a small space and to retrieve only those elements of immediate interest, within specific time frames, thus eliminating the necessity for field work each and every time that new coordinates are required, are advantages that stimulate the continuity of research in this area.

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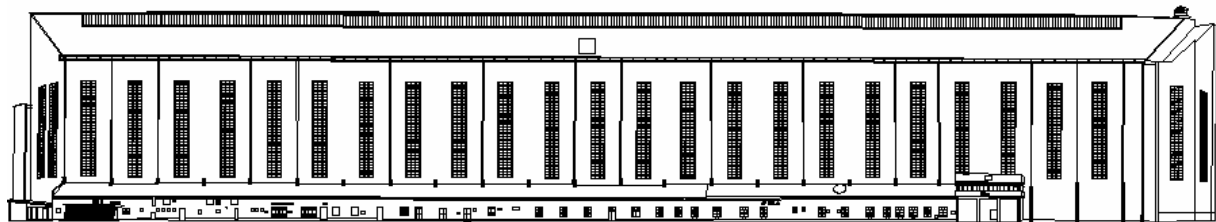
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- The Brazilian Air Force, Santa Cruz Airbase, present owner of the hangar, which took the aerial images in low altitude.

APPENDIX



Orthophotomosaic



Plot



Photo with AIRBUS-ACJ, instead of 3D model