# PHOTOGRAMMETRIC METHOD OF POST-CONSTRUCTIONAL SURVEY OF SHIP'S HULL IN SHIPIARD BUILDING SLIP

Andrzej Rachwał
District Enterprise for Geodesy and Cartography
in Szczecin, Poland

## INTRODUCTION

The ship's hull forms a surface, the mathematic equation for which hasn't yet been given in a simple way, applicable in every-day constructional practice. That's why one of the most broadly used manners of portraying the surface of a ship's hull is the graphic method.

The image of the hull surface, represented by means of theoretical lines, is shown in a system of rectangular coordinates, called the system of hull axes.

The system of coordinate axes of the hull is determined by: the plane of ship's symmetry xOz and two other planes perpendicular to it /fig.1/. They are:
- plane of midship bend zOy
- principal plane yOz.

Theoretical lines are obtained by intersecting the hull surface with three pencils of planes, parallel to the main planes of the hull.

The line of intersection of the hull with the waterplane /the plane parallel to the principal plane/ or projection of this line on any plane of the system of hull coordinates is called the designed waterline.

The line of intersection of the hull withm the framing plane /the plane parellel to the plane of midship bend/ or the projection of this line on any plane of the system of hull coordinates is called the frame line.

The line of intersection of the hull with the buttock plane /the plane parallel to the symmetry plane/ or the projection of this line on any plane of the system of hull coordinates, is called the buttock line.

All three kinds of lines are diagrammed on each of the three main projections: longitudinal /fig. 2a/, horizontal /fig. 2b/ and transverse /fig. 2c/.

The graph of theoretical lines is not a dimmensional drawing, but should as accurately as possible present the designed surface of a ship's hull. The cartographic accurateness of such a drawing is characterized by a mean error ± 0,1 mm. It is an initial drawing for all subsequent designing and calculation operations as well as for technological and constructional work connected directly with building of a ship.

For hull building purposes, besides a graph of ship's theoretical lines, also so-called drawing of square stations is made. This drawing represents the theoretical shape of frames edges at internal side of bottom and side plating.

Any doviation from theoretical lines given in the drawing may bring about serious irregularities in the construction of a ship. In consequence, diserepencies with the given shape may bo the cause of deficiency of cargo carrying capacity, inerease of drag, reduce of stability and endurance characteristies, what in turn may result not

anly in docrease of economic efficiency, but even in danger to the safety of navigation.

That is why of great practical importance are post-constructional surveys of the ship's hull surface, enabling as well quantitative comparison of the surface of a constructed hull with the designed surface, as localization of eventual major discrepancies in assembly.

## OUTDOOR SURVEY OPERATIONS

The post-constructional survey of a ship's hull in the shipbuilding slip may be executed by a geodesic method, e.g. applying spatial intersoction.

The advantage of this method is the possibility of attaining, with proporly indicated measuremont points, a high accuracy in determining the position of the point /of 2 mm order/. [6]
This method, however, requires much time and labour from the operating outdoor survey staff, because they must indicate and determine by spatial intersection the position of a great number of points.Great number of mesuring points is connected with the intricate shape of the ship's hull.
Also the disadventage of this method is the fact, that the results of the survey of the whole hull may bo obtained only after many days lasting measurements.
In consequence, the changes which in the meantime take place in the object being under survey, remain not recorded.
In this situation, according to the author, the best method to be applied when performing post-constructional survey of the ship's hull in the building slip, is the ground stereophotogrammetry.
This method needs but a little of autdoor operations /geodetic measurements of photopoints, taking photographs/, and what's more, the contents of information about the object given in a stereogram are much wider than those given in result of measurements taken by traditional geodetic methods.

The stereophotogrammetric measurements connected with post-constructional survey of the ship's hull have been carried out in the Shipyard dooks of Szczecin, named A.Warski.

On the side plating of the hull there have been marked with white paint 80 photopoints disposed evenly on three levels in such distances from each other that on each stereogram six photopoints could be photographically evidenced.
Arrangement and number of photopoints on a stereogram have great influence on accuracy of determining coordinates of ground measured points [2].
The measurement of photopoints has been executed with geodetic method, applying intersections from bases situated in a straight line parallel to the symmetry plane of the ship's hull and distant from it 25 m.
The angles been measured in two series with Kern theodolite DKM 2M.
Small distances between building slips and massing of yard's equpment and ships'sections within the region of the hull under survey, have made convenient positioning of surveying photogrammetric camera very difficult. In this situation the camera has been set up on the adjacent ship's hull. A main factor when deciding about survey positions was the possibility of covering the ship's hull with stereograms in whole and in most advantegeous manner /small distance of the survey position from the object, basic proportion being 1/4 /.

Since the survey has been performed in inconvenient conditions during routine work in the yard, the spatial positioning of the camera has not been determined and orientation has been made in an approximative manner, setting up the longest edge of the camera about parallel to the slip.

All photographs have been taken with Zeiss camera UMK 10/1318 on glass plates TO 1.

## INDOOR STUDY OPERATIONS.

The photogrammetric images of the ship's hull have been elaborated with analytic method. It was possible since the side plating frames were marked by tra traces left by a torch when heating side plating alongside the frames in order to straighten it, or marked with chalk.

The photographs have been observed in a stecometre with Zeiss coordimetre E. On each frame such a number of points have been surveyed which would in an explicit way enable reproducing the actual shape of a frame in space. The observation has been performed in such a manner as to have perforated tapes with results correspond to the set of calculation programmes worked out by Geodesy and Cartography Institute for the digital computer ODRA 1204 [3].

The survey coordinates have been calculated by the method of independent model, applying following programmes [3] :

OWT - working out of surveyed background coordinates,
MOD - calculation of model coordinates
TPO - spatial orthogonal transformation

In result of the above calculations the programme write-ups containing specification of coordinates of points on ship's hull have been obtained. On the basis of these coordinates a numerical record of the shape of actual frames has been made by means of a programme of mapping the lines in the ASTER system, elaborated by ZIPO in Gdańsk.

The results of the post-constructional survey of the ship's hull have been presented in a graphic form. On the drawing representing designet frames of hull in red colour has been graphed a drawing representing actual frames in black colour. Since the drawing of designed frames represente the shape of frames by the inner side of the side and bottom plating, and the drawing of actual frames - the shape on the outer side of the plating, it is necessary - when analysing these two graphs as a whole - to take into account the thickness of sheets of the side and bottom plating given on a collective drawing.

The above mentioned drawing has been executed using the automatic drawing desk, basing on the numerical record of the designed frames shape /red colour/ and actual frames /black colour/ on one sheet of tracing foil.

This drawing has been executed in 1:10 scale with accuracy $\pm$0,1mm. In order to improve readability of the drawing, only a part of the frames have been pictured, but this part, according to the author, should in an explicit way show discrepancies between the designed and actual shape of the ship's hull.

## ANALISIS OF RESULTS

Evaluation of the internal accuracy of post-constructional ship's hull survey has been effected by means of formulas for survey executed by paris. As a pair of observations have been here taken twice independently done determinations of coordinates of the same point from two different stereograms. These points have been situated in the strip double-covered by two adjoining stereograms. For the analysis purposes have been taken 47 points situated all over the ship's hull.

Every coordinate has been analysed separately, calculating mean error of a point position along the axis x,y,z, by a formula for a mean error of a single survey :

$$m_k = \pm \sqrt{\frac{d_k \, d_k}{2n}}$$

where:

d - a difference k-th coordinate i - of this point from the first and the second survey /k = x, y, z/ ,

n - number of pairs of observations.

The errors calculated upon the above formula are :

$$m_x = \pm 4{,}6 \text{ mm}; \quad m_y = \pm 5{,}3 \text{ mm}; \quad m_z = \pm 3{,}1 \text{ mm}.$$

The mean error of the position of a point, calculated upon the formula :

$$m_p = \pm \sqrt{m_x^2 + m_y^2 + m_z^2}$$

equals $\pm$ 7,7 mm.

According to the author's opinion, a decisive influence on extent of this error had an error in identification of points during observation in stecometre. This error could have been greatly reduced by pinholing the points on photoplates /left photograph/. As it is known, for this purpose serves a device "Transmark" made by Zeiss.

Making use with the above described method of the device "Transmark", it would be possible to obtain more exact data. In this instance the mean error of the point position on the ship's hull could be diminished to $\pm$ 5 mm.

At the it should be mentioned that in the survey of such a character, the photogrammetric method is now being unmatched. It enables in a comparatively short time to obtain full information about the real shape of the ship's hull, what is of great importance to the technologic staff of the shipyard.

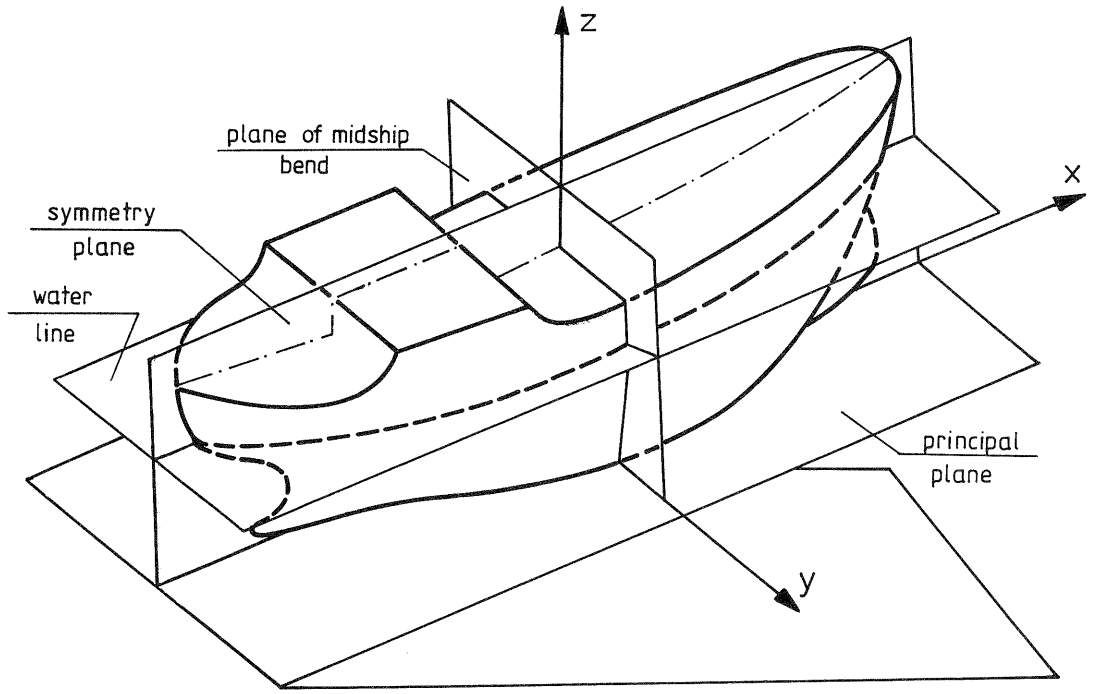
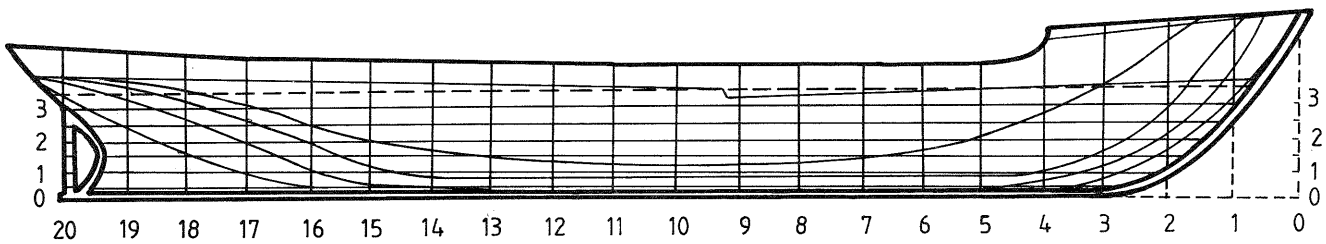

z
plane of midship
bend
x
symmetry
plane
water
line
principal
plane
y

Fig.1

a)



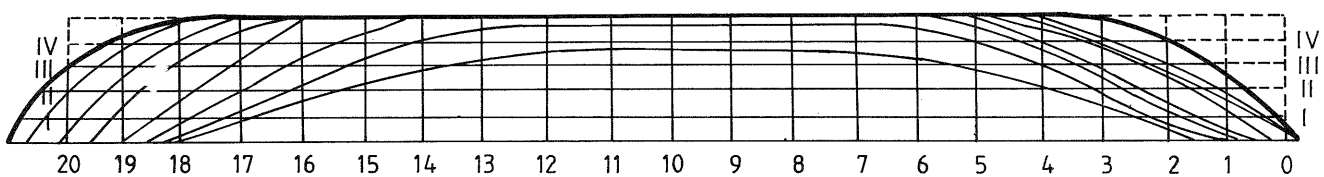

LONGITUDINAL PROJECTION

frames - vertical lines

water lines - horizontal lines

buttock lines - curved lines

b)



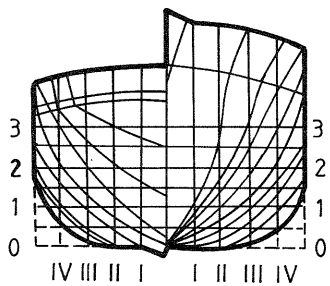

HORIZONTAL PROJECTION

frames - vertical lines

water lines - curved lines

buttock lines - horizontal lines

c)




TRANSVERSAL PROJECTION

frames - curved lines

water lines - horizontal lines

buttock lines - vertical lines

Fig. 2

BIBLIOGRAPHY


1. Doerffer J.: Technology of ship's hull construction. Gdynia, 1963.
2. Mizerski W.: Analysis and criteria of choosing the most adequate method for analytic elaboration of photogrammetric ground images /doctor's thesis/. Warszawa, 1977.
3. Mizerski W., Szczepański J.: System of calculating the outdoor survey coordinates upon photogrammetric ground images. Work of Geodesy and Cartography Institute. Warszawa, 1976.
4. Niebylski J.: Methods of geodetic survey for purposes of assembly and examination of deformation of sea vessels /doctor's thesis/. Kraków, 1976.
5. Guide-book of ahipbuilding engineer. Collective work. volume II. Gdynia, 1960.
6. Sejut Z.: Analysis of accuracy in survey of high-positioned points, inaccessible to the spatial intersection method, for the purposes of examination of deformations and executive survey. Geodesy and Cartography. Volume X, fascicle 3-4. Warszawa, 1961.