

A SPECIFICATION FOR THE ARCHITECTURAL PHOTOGRAMMETRIC SURVEY OF HISTORIC BUILDINGS AND MONUMENTS

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INTRODUCTION The growth in the use of Architectural Photogrammetry during the last twenty years has been considerable. Most of this work has however been carried out through the Public Sector in many countries. For example, one of the earliest such Departments set up was within the Bundesdenkmalamt in Austria, under the direction of Hans Foramitti (Foramitti, 1966). Similarly in Belgium the Ministere de Travaux Publics established a section for Architectural Photogrammetry in the early 1950s (Cattelain and Vermier, 1956). In France, much photogrammetric survey work was carried out through the Institut Geographique National (Carbonnell, 1968). In the United Kingdom, through the Photogrammetric Unit at the University of York the Historic Buildings and Monuments Commission for England has enjoyed a photogrammetric service for some twelve years (Dallas, 1983).

In all these cases, direct relations have existed between the Architects, Architectural Historians, Archaeologists and the many other professional disciplines involved in the care of historic Monuments. Because of this, standards of such workmanship in relation to detail to be drawn, accuracy, presentation, etc., were mutually understood. However, in a number of countries in recent years there has been a considerable move towards the provision of architectural photogrammetric surveys through the commercial survey sector.

This is to be welcomed, as indeed it must lead to the wider examination, knowledge and understanding of the use of photogrammetry in this important field. However, it does lead to its own problems, in that commercial survey companies may not be familiar with the purpose and standard of surveys which are required. It is believed that survey companies are more than capable of providing the high standards of survey work wanted, but it is also noted from considerable experience that they have on occasion not provided the product which is required, due it is believed largely to lack of communication and an appropriate Specification.

It should also be noted in the Introduction to this paper that it discusses the use of photogrammetric surveys to provide the highest standard of survey of major historic buildings and Monuments. Where the use of photogrammetry is merely a means to an end to provide surveys, say of streetscapes at small scales, then it is not believed that the detailed provisions of this Specification should apply.

This Specification is designed to produce the highest standard of survey on our most important Historic Buildings.

This Specification has been prepared by the writer on behalf of the Historic Buildings and Monuments Commission for England, more commonly known as 'English Heritage'. It has been in use for a fairly short period of time, and is still in the process of revision. It has been written in the context of conditions met with in the United Kingdom. It is not expected that other photogrammetrists in other countries will necessarily agree with every point in it. Rather, its publication is designed to make us all think along the lines of the requirements of such a Specification appropriate to our own country and method of use of photogrammetry. It could be used directly, but it may often be more useful to redraft it with paragraphs and detail appropriate to local circumstances.

There are however a number of important themes which influence the content of the Specification, and the following notes will amplify these points. In each case the numbers in parenthesis refer to the specific paragraph of the Specification.

DEFINITION OF PHOTOGRAMMETRY (Para 1.2) It is surprising that many photogrammetric surveys are purchased without attempting to define what a photogrammetric survey should comprise. While an exacting definition of photogrammetry has exercised many minds in the photogrammetric world over many years, for the present purpose it seems only necessary to provide a simple definition to include the general principles of such work. That is, the use of metric cameras, commonly accepted photogrammetric plotters, the principle of measuring from stereomodels and providing a suitable control framework. In general, however, the Specification does not attempt to tie the Consultant to a precise method. It defines the principles, the standards and the products, but leaves the methodology to the Consultant.

THE ARCHIVAL VALUE OF PHOTOGRAMMETRIC SURVEYS (Para 1.3) Many survey companies are involved in the production of surveys for immediate use, for example in the design of engineering work such as motorways, bridges, etc. The short-term life of these surveys often conditions the attitude of the survey company. It is therefore felt essential to spell out that **photogrammetric surveys of Historic Buildings are archival products**. We would not expect to have to commission another such survey for fifty or a hundred years. The work must therefore be carried out to the highest possible standards, and we must make sure that all the accompanying data is properly stored and recorded.

PHOTOGRAPHY (Section 2.0) While many interesting developments in close range photogrammetry in recent years have concerned the use of non-metric cameras, it is strongly felt that for the foreseeable future the basis of production surveys in the architectural field must continue to be photography taken with conventional metric cameras. We can stretch a point to make use of cameras such as the Rolleiflex partial metric camera system, but it will still normally be expected that the bulk of photography will be taken with conventional metric cameras

(Para 2.1). Again, with the new generation of analytical plotters, for difficult problems much can be achieved with very tilted photography. However, whenever possible for the plotting of large or elaborate facades, photography should normally be taken parallel to the facade with the exception of Absolute Omega (Para 2.3). This will provide properly conditioned stereopairs, so that a stereomodel can be observed and continuous line plotting is possible.

Survey companies are often conditioned to attempting to work to the highest possible enlargement factor. This of course is to obtain economies, and six times enlargement from aerial photography to plotting scale is common. In the experience of the writer, however, this is rarely satisfactory for architectural work. This is for two reasons: first, in order to provide the best possible interpretation of typical architectural detail, experience has shown that the smallest satisfactory negative scale is around 1:150. Second, it has been noted over the years that there is a steady progression towards the requirement for larger scales for the drawings. In the past, many Architects used scales of 1:100 for surveys of buildings. With the introduction of photogrammetry, 1:50 scale is commonly used. With the widespread input of archaeologists nowadays to the recording of buildings, 1:20 scales have become much commoner. For the precise detailing of repairworks to complicated structures, 1:10 scales are nowadays being requested. It therefore seems prudent to take our photography at scales which will enable us at the least to produce 1:20 scale plots in years to come (Para 2.4).

CONTROL MEASUREMENTS (Section 3.0) It is very important to define the method to be used for the establishment of control. This is because in the experience of the writer most customers for photogrammetric surveys are usually ignorant of the systems of control and their implications. For example, while the majority of survey companies would work to the principle of providing control by theodolite observed points, without specification there is in reality nothing to stop a company providing control by tape and distance measurements only. This could lead to inaccuracy in the survey, but also could seriously reduce the long term archival value of the product. Therefore, for most surveys it must be considered that the norm will be to have theodolite observed control, consisting of a traverse run round and through the building followed by the intersection of suitably observed points on the facade (Para 3.1 and 3.2). For the great majority of work, variations to this basic principle and method are not advised.

Reference is made (Para 3.3) to the use of targets to be affixed to the facade to provide suitable points for the control. This is not strictly speaking necessary, but in the experience of the writer the value of targetted points is inestimable. Although it takes some time to attach targets, once they are on the facade their observation and subsequent identification on the plotting machine is very reliable. The use of natural detail on the other hand involves the drawing of sketches, and is highly error prone.

PLOTTING OF THE SURVEY (Section 4.0) Sections 2 and 3 define the standards of photography and control. If this information has all been followed, an excellent set of stereo photography should now be available. The definition of the detail and standard to which it is drawn on the plot is one of the most vital areas of any photogrammetric survey, but at the same time is also one of the most difficult to define. It is easy to simply list the features which are to be drawn, but if the photogrammetric operator has a poor understanding of how vitally important it is to precisely delineate detail then the final product will be unsatisfactory.

Some rules can however be established. In regular production work, it is not considered possible to produce high quality photogrammetric plots in any volume using anything other than a plotter which provides a continuous line plotting facility, ie either an analogue or analytical plotter. 'Four axis' machines which basically measure in a point-by-point mode have a very limited capacity for producing the standards of work which are required in the preparation of highly detailed drawings of historic Monuments (Para 4.1). The use of diapositives (Para 4.4) is also recommended as a very strong aid to obtaining the best quality of drafting. Interpretation from negatives will not provide plotting to the same standard as can be obtained from good diapositives.

It is most important that the client for the survey should accurately state the amount of detail (Para 4.6) which is to be shown on the survey. Normally all architectural detail will be shown. In the case of historic Monuments it is also usually the case that all individual blocks of stone will be delineated. However, with some types of surface such as flint or brick it will not normally be practical or of value to draw out every single feature. Also the definition of repetitive features must be considered. There will usually be little value in drawing out the repetitive detail of for example, a frieze, or a large number of say Corinthian capitals.

A very important principle of the work undertaken by the York Unit is to ensure the 'purity' of the primary photogrammetric record. This plot should have no redrafting if possible, and no use should be made of photo-repeat or CAD methods for repetitive features (Para 4.9 and 4.10). Arrangements for the completion of blank areas of the survey and the checking of any mis-interpretations must then be made (Para 4.11). These should be decided in consultation with the survey company or with independent archaeological or architectural trained staff, having assessed their capability of completing the drawings to the high standards required.

PRESENTATION (Section 5.0) The presentation of the material will obviously very much relate to the established customs of the country, and of the Client who is acquiring the material. Minor points are that the drawings should all be carried out on standard 'A' size sheets, with appropriate keys and grids, etc. The supply of data in digital form is considered to be an important aspect. There are clearly many different systems of

data acquisition in digital form, and many organisations may still not have full facilities available for the use of this material. However it is strongly recommended that the supplier of the survey is asked to record his data digitally, and either supply this or keep it until such time as the organisation is able to make use of it directly (Para 5.7).

It is also strongly recommended that **an advance copy of a small part of the survey is prepared** (Para 5.6). This could be either one stereomodel, or an area defined as so many square metres. This should be supplied as a provisional plot, and used by the Client to decide if the correct amount of detail and other information is being drawn out. However, in fairness to the Consultant a time limit must be placed on the period available to the Client to assess the suitability of the sample.

Finally, the archival importance of all photogrammetric surveys has already been referred to. It is most important that the Consultant be asked to provide a properly prepared and indexed set of data to support the drawings (Para 5.8). This should consist of the items listed in the Specification, and the material should be not only supplied but should be in appropriate packaging.

LEGAL CLAUSES In this version of the Specification, no 'legal' clauses have been included. Such clauses would relate to access, liability, insurance, time penalties, etc. This material has not been included, since it is felt that most Client organisations have their own standard material for this purpose, and also circumstances are so different from one country to the next.

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**STANDARD SPECIFICATION
FOR ARCHITECTURAL PHOTOGRAMMETRIC SURVEYS : SECTION A**

1.0 INTRODUCTORY NOTE

1.1* This Specification provides a detailed statement of the standard required for the provision of an architectural photogrammetric survey of SECTION 'B' describes the areas of the building or Monument to be surveyed, and notes any variable details.

1.2 Architectural photogrammetric surveys are defined as surveys where the building or Monument is photographed with a 'metric' or similarly approved camera in such a manner as to produce overlapping stereomodels of areas of the facades. These stereomodels are then set up in an approved type of photogrammetric plotting machine, and line drawings or appropriate digital products are derived by measurement from the stereomodel.

1.3 The attention of photogrammetric survey companies, hereafter referred to as the Consultants, is drawn to the fact that the completed photogrammetric survey will form an archival record of the Monument, comprising both the 'metric' photographic record and the line drawings.

1.4 The attention of the Consultant is also drawn to the historic importance of the building or Monument. No action must be taken which could lead to damage to the building or Monument, and any markings must be removable without trace.

2.0 PHOTOGRAPHY

2.1 All photography will be taken with an approved type of 'metric' camera, from the ranges manufactured by Wild (Heerbrugg), Zeiss (Oberkochen), or Zeiss (Jena), or other such makes as may be approved by the Client. The choice of appropriate cameras will normally be left to the Consultant, but details of the cameras used for the survey must be supplied on completion of the project.

2.2 All areas of the building or Monument for which a survey has been requested are to be covered in suitably arranged stereoscopic overlaps to form stereomodels capable of restitution in photogrammetric plotters. Base to distance ratios should not normally exceed 1:4, and the stereo overlap should be not less than 60% of the area of each stereopair.

2.3 In general, photography must be taken within plus or minus three degrees of parallel to the appropriate area of facade, and with both photographs of a stereopair within 5% scale variation of each other. For absolute Omega, it is acceptable to use tilts of maximum fifteen degrees either upwards or downwards to the section of facade. Where Consultants consider it was necessary to work outwith these parameters, they should list such photography in the final presentation.

2.4* The smallest permissible photographic negative scale will normally be defined as follows:

- For 1:50 scale plotting, negative scales should be no smaller than 1:200.
- For 1:20 scale plotting, negative scale should be no smaller than 1:80.

For any variation, see SECTION 'B'.

2.5* In general all photography will be taken on black and

white negative film, such as Kodak PLUS-X or Ilford FP4 or approved equivalent. It should be exposed and processed to ensure high quality definition. The negatives must be processed to an archival standard, ie fix and wash in accordance with the film Manufacturer's specification. The Consultant must ensure that the metric camera is used in accordance with the Manufacturer's instructions, such that film flatness tolerances and lens distortion values, etc are within the Manufacturer's allowances. If special films or colour photography is required this will be detailed in SECTION 'B'.

2.6 Attention must be paid to the lighting conditions affecting the area of facade at the time of photography. Photography with harsh shadows may be rejected if it is not possible to see all detail when studied in stereo.

2.7 The use of non-metric cameras may be acceptable, but if the Consultant proposes to use such cameras details of the camera and distortion correction system must be supplied with the Consultant's tender documents. The Client reserves the right to reject specific cameras if it is felt that the results will not be of an acceptable standard.

3.0 CONTROL MEASUREMENTS

3.1 The control system is defined as the series of measurements made on site which will allow for the restitution of each of the stereomodels with an exactly defined scale, datum and relationship to each other.

3.2 Normally the stereomodels will be controlled by the provision of a minimum of 3 three-dimensional co-ordinated points located within the area of each stereomodel on the facade, and observed by theodolite from stations on a traverse around and through the building or Monument.

3.3* The control survey for the stereomodels will be integrated into a GRID established for the whole building or Monument, or such part of it as this Specification refers to. For the approximate origin and orientation see SECTION 'B'.

3.4* At least three of the traverse stations will be marked by the insertion of permanent ground markers, design to be approved. However, as there may be underground undisturbed archaeological detail, acceptable positions on site of these ground markers will be discussed with the Client. SECTION 'B'.

3.5* Where a photogrammetric or other survey has already been undertaken on the site, the control stations of that survey are to be relocated and reused with coordinate values supplied by the Client. However, the Consultant must satisfy himself that the existing co-ordinates supplied meet the required standard of accuracy for the current survey. SECTION 'B'.

3.6 Wherever possible targets should be fixed to the facade, but where this is not possible points of detail should be used. If points of detail are used appropriate diagrams describing these points must accompany the final presentation.

3.7 Bundle adjustment methods may be used for the control of blocks of stereomodels, but details must be provided.

3.8 ACCURACY. The maximum error in the closure of the traverse shall be not more than plus or minus 10mm.

3.9 ACCURACY. For control points observed by 2-point theodolite intersection, the difference in the height value obtained by computation from the left and from the right hand

stations will not exceed 5mm.

3.10 The heighting of the survey will normally be related to the National levelling system, using two level points on that system if available. The locations, descriptions and values of the bench marks must be stated in the final survey data. On sites where site bench marks have previously been established the location and height values will be supplied by the Client.

3.11 Within the principles stated above, details of the exact scheme used to provide the control for the survey will be the responsibility of the Consultant. Consultants may offer an alternative scheme for control with the returned Tender documents. The Client reserves the right to refuse to accept these proposals if in their opinion the defined standards of accuracy will not be achieved.

4.0 STEREO PLOTTING

4.1 All stereo plotting will take place on an approved type of photogrammetric plotter. It is expected that Consultants will make use of photogrammetric instrumentation of the type considered standard in photogrammetric survey, ie. topographic plotters such as the Zeiss (Oberkochen) Topocart, Wild A8, or Thompson-Watts, or analytical plotters such as the Officine Gallileo Digicart, Kern DSR 1 or 11, or Wild BC2. Point-by-point measuring systems such as the Rollei 'Rolleimetric', the Zeiss (Jena) Steco 18 18, or the Zeiss (Oberkochen) Stereocord, will not normally be considered as acceptable instruments for the production of the photogrammetric line drawings.

4.2 The choice of plotting method will be the responsibility of the Consultant, but Consultants are reminded of the high standard of detail recording and accuracy required of the survey. If, for example, digital point/time recording modes are employed it is expected that a very high density of points equivalent perhaps to a point every 20mm to 30mm at 1:1 scale will be utilised.

4.3* The plot scales normally employed will be 1:50 or 1:20, or a combination of both. SECTION 'B'

4.4 All plotting will be carried out from DIAPOSITIVES. These will be prepared in accordance with accepted procedure in the photogrammetric industry.

4.5 ACCURACY. All stereomodels will be set up such that the residuals in X, Y and Z at the control points will not exceed 0.2 mm at the specified plot scale. As regards the plotting of detail, the position of any well defined detail will not be in error in X, Y or Z by more than 0.3 mm in relation to the nearest control point.

4.6* **DETAIL.** Consultants are reminded that the greatest care must be taken to ensure the accurate depiction of detail.

The following categories of detail should be drawn:

(a) All architectural and associated decorative detail, ie windows, doors, quoins, string courses, roof lines, etc., and the stonework jointing of such features, is to be drawn out as fully as can possibly be shown at the agreed plotting scale.

(b) For large or small repetitive features, eg. windows, capitals, mouldings, full or sample plotting will be specified.

(c) On sculptural features, or elaborately carved architectural detail such as capitals, guidance will be given as to how much detail is to be drawn.

(d) Where the facade is of stone, each individual stone should be delineated. At 1:50 scale work, where there is good ashlar a single line between joints will normally be considered satisfactory. If however, the stone is irregular or the width of joints exceeds 30 mm, joints should be plotted on both sides. At 1:20 scale it will be normal practice to draw all joints, except where very fine ashlar is present.

(e) For other walling materials, eg brickwork, it will not normally be necessary to draw individual features.

(f) Features such as putlog holes, structural cracks, rainwater goods, etc should be plotted if requested.

- For variations see SECTION 'B'.

4.7 The survey is to be presented as an UNVERIFIED PHOTOGRAMMETRIC MACHINE PLOT. A single linewidth of 0.18mm to 0.2mm will be used throughout. No heavying up of such features as the edges of buttresses is required, nor is it necessary to annotate the plot with written descriptions.

4.8 In general, a single solid ink line as defined above should be used to show all architectural detail. However, where erosion has affected the sharpness of detail the following guidance should apply:

- The solid line should be used when the curvature of the edge between two planes, or between a plane and a void, is not more than 20mm wide.

- A dotted line should be used where the curvature of the edge spreads between 20mm and 40mm.

- Over 40mm no attempt to draw the edge should be made.

These values refer to measurement on the facade, ie at 1:1 scale, and apply both to 1:20 and 1:50 plots.

4.9 In general, no re-drafting of linework is to take place. However, this condition may be relaxed where high enlargements between negative scale and plot scale were necessary. If it is the Consultant's opinion that such re-drafting of specific areas is advisable he should discuss with the Client.

4.10 Photo-repeats or CAD generated repeats must not be used. Even on a row of apparently identical windows or capitals, each individual feature must be drawn out through the stereo plotting machine.

4.11* If the Consultant is required to carry out verification of the plot, or the hand completion of areas of the facade which are obscured due to vegetation or other obstruction, this will be detailed in SECTION 'B'. Otherwise, such completion work will NOT form part of this Contract.

4.12* Photogrammetrically derived horizontal and vertical cross-sections may be required as specified. SECTION 'B'

5.0 PRESENTATION AND DELIVERY OF THE MATERIAL

5.1 The drawings will be presented as line drawings, using black ink lines on matt surface stable polyester film of thickness minimum 0.005 inch.

5.2 Two copies of each sheet of drawing will be provided. These may be two reprographically reproduced copies, or they may consist of one original drawing sheet and one copy.

5.3* All drawings will be produced on standard A size sheets. The sheet size, style and information panel will be to a design approved by the Client. SECTION 'B'

5.4 Grid marks will be placed on the sheets, such that it is

possible to fit the sheets over a standard 100mm by 100mm grid. The height values related to the bench mark will be shown down the left and right hand edge of the sheet.

5.5* The sheet layout will be discussed with the Client before presentation of the final drawings. Consultants may, for example, be asked to leave areas of sheets blank so that a hand measured area of the structure can be added. SECTION 'B'

5.6* A paper copy of a sample stereomodel plot or agreed area will be submitted to the Client for approval before work proceeds on the final drawings. The Client shall return the sample within ten working days, with a note of any amendments to the standard of drafting or detail to be drawn. SECTION 'B'

5.7* As well as drawings, the data may be requested in digital form, formatted suitable for use in a CAD system as specified. If not, but digital methods have been used for the data acquisition in any case, Consultants are asked to keep this data in store. SECTION 'B'

5.8 The following data will be supplied on completion of the Contract:

- Two sets of final drawings as detailed above.
- One set negatives, in individual archival sleeving.
- One set diapositives, in individual archival sleeving.
- Two sets black and white prints, one annotated with the position of control points.
- Diagrams showing photographic coverage.
- Diagrams showing traverses and control network.
- Camera and plotting machine model/calibration data.
- Listing of co-ordinates of control points and traverse stations.

SECTION B: VARIABLES

This section of the Specification should be drafted by the Client, to list all the variable factors affecting the survey, as indicated by an *asterisk in Section 'A'.

More complicated requirements should also be itemised here, eg. you may wish photography and control of part of the Monument, but no plotting to be carried out for the present.

- 1.1 Area of survey. Sketch plans/elevations should show as carefully as possible the area of survey.
- 2.4 Negative scale.
- 2.5 Variation on film, eg colour.
- 3.3 Grid origin and orientation.
- 3.4 Location of permanent markers.
- 3.5 Existing survey information.
- 4.3 Plotting scale.
- 4.6 Detail to be plotted. **It is most important to define the detail to be plotted thoroughly.**
- 4.11 Verification / completion.
- 4.12 Horizontal and vertical cross sections.
- 5.3 Sheet size, style and information panel.
- 5.5 Layout of drawings on sheets.
- 5.6 Sample plot area.
- 5.8 Provision of data in digital form.

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