

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS
FOR
CHECKING
PHOTOGRAMMETRIC MAPPING

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I N T R O D U C T I O N

The text of this manuscript was devised to formulate Standard Procedures and Methods for Checking Photogrammetric Mapping.

All photogrammetric mapping that is prepared for Department of Transportation's use, by others, must be checked for the maximum requirements as outlined in this "Manuscript", and the "State of Connecticut, Department of Transportation's Specifications for Aerial Photography and Photogrammetric Mapping" (revised to date), and the "State of Connecticut, State Highway Department, Location Survey Manual", (revised to date).

SECTION I

Definitions

Aerial Negative: The original instrument produced by the aerial camera and a developing process from which all contact prints or enlargements are produced. The negative's effective dimensions are 9" x 9".

Aerial Photographs Oblique: Photographs taken at any angle below the horizon except 90° to be used primarily for exhibition and environmental studies.

Aerial Photograph Vertical: A photograph taken from an aircraft with the longitudinal axis of the camera as nearly vertical as is possible.

Control, Ground: Horizontal and vertical traversed or triangulated ground controlled points necessary to accurately relate the aerial photograph to the corresponding portion of the earth's surface.

Control, Horizontal Ground: The surveyed control necessary to position and identify particular points on the ground as to their correct geographic or plane coordinate positions, within certain specified limits or error, that may appear on the photographs as panels.

Control, Vertical Ground: The control necessary to establish a point's height above an established datum plane.

Crab: The angular displacement of the axis of the negative from the flight line. Crab in excess of five (5) degrees may be cause for rejection of the flight line of negatives or portion thereof in which crab occurs.

Flight Line or Flight Strip: Either the flight path of the aircraft containing the camera or the strip of photographs produced from a single flight.

Fuducial Marks: Indicators produced on each border of the negative at the moment of exposure to facilitiate the location of the photograph's principal point.

Manuscript or Base Map: The original master negative upon which the data gathered from the aerial photographs has been compiled.

Map - Photogrammetric: An orthographically projected representation of the existing physical land features for the area depicted, which may or may not include elevation, produced through the utilization of a stereo-plotting instrument.

Map - Planimetric: A reproducible copy of the manuscript showing existing physical features of an area without elevation indicators.

Map - Topographic: A reproducible copy of the manuscript showing existing physical features of an area with contours and/or spot elevations.

Model: The area produced by the end lapping of two successive aerial photographs. A model is the product of two photographs depicting the same ground area but taken from two different positions of exposure.

Mosaic: The finished, assembled and matched photographs to produce a large, single picture of the area involved. Only a portion of each print is utilized in the construction of a mosaic and the lines of junction between the photographs are concealed as much as possible.

Mosaic - Controlled: One in which each photograph has been scaled and rectified and the match is as near perfect as possible.

Mosaic - Uncontrolled: One in which no effort has been made to scale ratio or rectify the prints involved. The photographs are matched as well as the variance of scale and tilt will permit.

Overlap: The overlap shall be sufficient to provide full stereoscopic coverage as follows:

- a. Boundaries: All the area appearing on the first and the last negative in each flight line extending over a boundary shall be outside the boundary of the project area. A photograph strip along a boundary shall extend over the boundary not less than 15% or more than 55% of the width of the strip.
- b. End Lap: The end lap (overlap in line of flight) should not average less than approximately 57%. End lap of less than 55% or more than 65% in one or more negatives may be cause for rejection of the negative or negatives in which such deficiency or excess of end lap occurs, unless within a stereoscopic pair end lap exceeding 65% is necessary in areas of low elevation to attain the minimum 55% end lap in adjacent areas of high elevation.

Wherever there is a change in direction of the flight lines, vertical photography on the beginning of a forward section shall give complete stereoscopic coverage of the area contiguous to the forward and back section.

- c. Side Lap: The side lap (overlap of parallel strips of vertical photography) should average 25% or minus 10%. Any negatives having side lap less than 15% or more than 55% may be rejected.

Panels: Identifiable ground control points that have been marked in such a manner as to insure their appearance on the aerial photographs.

Plane Coordinate Systems: Any numerical identification system based on a series of evenly spaced grid lines, usually parallel and at right angles to one another, that will accurately relate the position of any particular point to the position of any other point similarly identified on an area, state, nation or worldwide basis. All U. S. C. & G. S. first, second and third order traverse and triangulation stations located in Connecticut are identified both on a national geographic positioning system and on the Connecticut Plane Coordinate System. A coordinate system may be assumed for any particular area if ties to an existing system are uneconomical or unjustified.

Photogrammetry: The science of obtaining accurate measurements through the use of photographs.

Photographic Index: A composite photograph of the individually overlapped photographs assembled in an approximate relationship to each other. The index is usually produced at a scale one third (1/3) that of the original photographs.

Principal Point: The intersection of the two lines drawn through opposite fiducial marks physically locates the principal point on the photograph. The principal point is an imaginary intersection of the elongation of the camera's longitudinal axis and the ground. If no tilt is present, this elongation would be a plumb line.

Print - Check: A blue or black line print of either the manuscript or the contact positive used in the field and/or office in checking the accuracy of the manuscript and as a work copy.

Print - Contact: A same scale positive print of the negative on a suitably selected base material.

Print - Cronapaque: A mylar type, emulsion coated material with a very low coefficient of expansion and extreme durability upon which the contact print or an enlargement of the negative may be produced.

Print - Paper: An emulsion coated, high grade paper used for the same purposes as the cronapaque print, but available in single or double weights and gloss, semi-matte or matte finishes.

Rectification: The process of producing a truly vertical photographic print from a tilted aerial negative.

Relief - Effect of: Topographical relief causes radial displacement of the photographic images of ground points. For any given flight, this displacement is proportional to the height of the point above or below the datum plane and to the radial distance between the nadir (plumb) point and the displaced point. High points are displaced outward from the nadir point and low points are displaced inward this point. Thus, a high point near the edge of an area to be photographed could be displaced so far perspectivevely as to not appear on the photographic format.

Scribing: A drafting process whereby the penciled lines produced by the stereoplotter operator are followed with an edged tool that removes the coating on the manuscript to expose the transparent plastic base. This method produces the original map as a negative which greatly facilitates the reproduction processes that follow.

Scribe Coat: A type of manuscript material which consists of a plastic film coated with a colored emulsion which is utilized in the scribing process.

Spot Elevations: The elevation of a particular point on the map. Such points are indicated by a small "X" or by the decimal point of the elevation recorded. Cross section data are secured from a series of spot elevations.

Stereoplotter: A multiple projector or optical train mapping instrument capable of producing a rectified, scaled and stereoscopic model image of two aerial photographs on a manuscript surface.

Sun Angle and Weather: Photography shall be undertaken only when well-defined images can be obtained. Photography should not be attempted when the ground is obscured by haze, smoke, dust or when clouds or cloud shadows will appear on more than 5% of the area of any one photograph. Photography shall not contain shadows caused by topographic relief and sun angle, whenever such shadows can be avoided during the time of year the photography must be taken. Photography shall not be undertaken when the sun angle is more than 45 degrees from the true sun noon (zenith position of the sun for the exact longitude and time of the year) from the beginning of April through August,

or for the other seven months of the year, when the sun angle is more than 30 degrees from true sun noon. These angles are applicable for latitudes to 40 degrees north, and should be decreased appropriately for latitudes farther north.

Tilt: Negatives made with the optical axis of the aerial camera in a vertical position are desired. Tilt (departure of the aerial camera axis from a vertical line at time of exposure) of any negative by more than 3 degrees, an average tilt of more than 1 degree for the entire project, or tilt between any two successive negatives exceeding 4 degrees may be cause for rejection. Rectification to correct negatives having excess tilt may be permissible, provided photographic copy negatives are supplied.

Tilt - Effects of: Sidelap and endlap will be decreased on that portion of each aerial negative tilted above the plane of the vertical and will be increased on the portion tilted below the plane. For practical purposes, the increase or decrease in endlap and sidelap can be considered as 2 percent per degree of tilt.

SECTION II

General

The procedure for checking photogrammetric mapping will cover six (6) separate items and they are, as follows:

1. The accuracy and position of control monumentation and/or intermediate control points
2. Elevation control
3. Cultural features
4. Contours
5. Spot elevations
6. Final detail check

Before any photogrammetric mapping can be accepted by the Department as being within the tolerances of accuracies as set forth by the Department's Specifications for Aerial Photography and Photogrammetric Mapping; the above noted six (6) items must be checked for accuracy and completeness by using the methods outlined within this manuscript.

SECTION III

Procedures for Checking Photogrammetric Mapping

1. Monumentation and Intermediate Control Points:

Mapping that is being checked for monumentation and intermediate control points, shall be checked in the field using a minimum length of traverses as derived from the following formula.

$MA \times 2 \times MS =$ Minimum length of traverse in feet to be checked

MA = The area in square feet, within the perimeter of an orthographically projected representation of the earth and its features as shown on a single map sheet

MS = The scale of the map being checked

The location and accuracy required for horizontal positioning of control monumentation and intermediate points shall conform to the specifications outlined in the State of Connecticut, State Highway Department's Survey Manual, Section III (revised to date), and the State of Connecticut, Department of Transportation's Specifications for Aerial Photography and Photogrammetric Mapping, Division II, Section I, Paragraph C.

The District responsible for the review shall have the opportunity to review all horizontal control computations for procedure and accuracy prior to the start of any computations for stereo compilations.

The selection of traverses to be checked on each map shall be such, as to provide a good representation of the entire map.

The location of the traverses shall be at the discretion of the Division Engineer of Surveys for the District involved.

2. Elevation Control: A field check shall be made on all points designated for elevation control along or near the same traverse lines that are to be checked for horizontal position. The span of area to be covered between points shall be equal to or greater than, the amount for monumentation and intermediate control points.

The accuracy required, shall be as set forth in the State of Connecticut, Highway Department, Location Survey Manual, Section VIII (revised to date), and the State of Connecticut, Department of Transportation's Specifications for Aerial Photography and Photogrammetric Mapping, Division II, Section I, Paragraph C.

The District responsible for the checks shall have the opportunity to review all vertical control computations for procedure and accuracy prior to the start of any computations for stereo compilations.

3. Cultural Features: Cultural features shall be checked for accuracy of location and for features missing that may or may not be visible on the aerial photographs.

a. Checking cultural features for accuracy: The minimum number of angular and linear measurements required to check cultural features shall be computed as follows:

$$MA \times 2 \times \frac{MS}{40} = \text{number of angular and linear measurements required}$$

MA = The area in square feet, within the perimeter of an orthographically projected representation of the earth and its features as shown on a single map sheet

MS = The scale of the map being checked

There will, at times, be mapping which will have a minimal amount of cultural features that can be checked. In cases of this nature the reviewers, shall use discretion when checking such mapping, however, in no cases shall the total number of measurements in combination represent less than fifty (50) percent of the cultural features shown, when the required number of angular and linear measurement by formula cannot be met.

b. Checking cultural features for completeness: All mapping shall be visually reviewed in the field to insure that all cultural features are shown, that are visible on the aerial photographs using magnification. Should a question arise as to a cultural feature being visible or not on the aerial photographs, the reviewer shall through proper channels petition the Photogrammetrist to recheck the particular cultural features in question.

All cultural features that are missing and can be identified on the aerial photographs, shall be so noted, and the Photogrammetrist shall be required to plot all missing identifiable cultural features. Cultural features not identifiable on aerial photographs shall be located by ground surveying methods and plotted on their respective map sheets.

4. Contours: Contours shall be checked for location using the following methods:

- a. The minimum total number of contours to be checked shall be determined by the formula:

$$MA \times 2 \times \frac{MS}{40} = \text{number of contours to be checked}$$

MA = The area in square feet within the perimeter of an orthographically projected representation of the earth and its features as shown on a single map sheet

MS = The scale of the map being checked

- b. Contours shall be checked by taking an existing ground profile perpendicular to the plotted contours.
- c. A minimum of two thirds (2/3) of the required contours to be checked, shall be on open land with contours no closer than one and one half (1½) times the contour interval and no further apart than forty feet.

The remaining one third (1/3) may be checked in wooded areas having a minimum amount of shadows created by trees, brush, etc.

- d. Contours checked in areas obscured by woods, heavy brush and swamp shall be allowed two (2) times the error specified for the scale of mapping being checked.
- e. Contours may be shifted 0.025 thousandths of an inch on the map in order to retain vertical specifications.

5. Spot Elevations: Spot elevations shall be checked for accuracy and location as follows:

- a. Spot elevations shall be shown on mapping as indicated in the contract with the surveyor or Photogrammetrist and as specified in the State of Connecticut, Department of Transportation's Specifications for Aerial Photography and Photogrammetric Mapping.
- b. The minimum number of spot elevations to be checked shall be arrived at by the following formula:
$$MA \times 1.5 = \text{number of spot elevations to be checked}$$
$$MA = \text{The area in square feet within the perimeter of an orthographically projected representation of the earth and its features, as shown on a single map sheet.}$$

- c. Spot elevations shall be checked at random throughout the entire mapped area utilizing the required number of points to be checked.
- d. The accuracies specified in the State of Connecticut, Department of Transportation's Specifications for Aerial Photography and Photogrammetric Mapping, shall govern for checking spot elevations.

6. Final Check: When the Contractor has completed the mapping, including all miscellaneous field survey data and revisions as ordered, a final visual check will be made to determine the completeness of the maps.

SECTION IV

Determining a Rejected Sheet

The reviewer shall be guided by the results of the field checks for each sheet and the specifications for Photogrammetric Mapping when determining a rejection or acceptance of a map.

The reviewer shall keep in mind, the best interest of the Department at all times when determining the completeness and correctness of Photogrammetric Mapping. He shall also

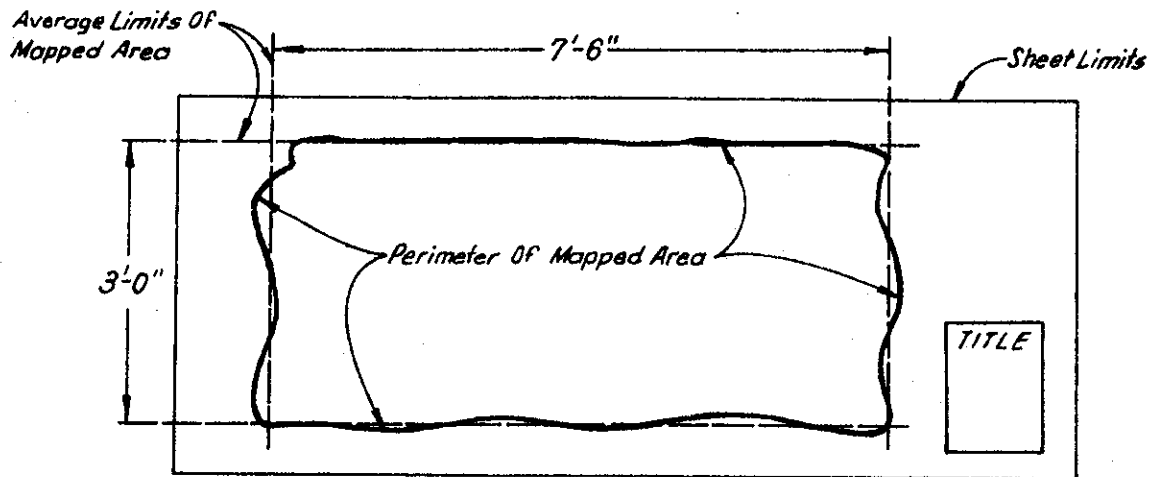
maintain a high degree of efficiency, since his findings could cause the Contractor to be unnecessarily penalized, also an improper determination could cause him to perform unnecessary work. Therefore, good judgment should be used when determining the rejection or acceptance of a sheet.

When obvious errors, such as uncontrollable printing distortions, resulting from paper shrinkage or stretch occurs, also drafting transpositions, etc., the reviewer shall, do to these types of errors, allow the required maximum amount of error to increase by two percent (2%).

Should a map, sheet fall within the allowable error plus the two percent (2%) leeway, of which the added two percent (2% consists of obvious errors, the sheet shall be accepted subject to minor revisions. All sheets that do not meet the requirements and that have numerous drafting errors etc., that would cause a sheet to exceed the two percent (2%) leeway shall be rejected.

All sheets, that do meet the requirements, shall be considered as approved and/or approved subject to minor revisions.

DETERMINING THE MAPPED AREA



1. Visually estimate and scale, in feet, a rectangular outline of the area actually mapped on the sheet, using an average for each side.

2. Determine an area in square feet from the previously scaled dimensions. The establishment of precise areas are not required since the Engineer in charge, has at his discretion, the option of increasing the square foot figure, if he so desires. The Mapped Area is the basis for computing all quantities for each item to be checked on photogrammetric mapping.

DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
AERIAL MAP FIELD CHECK

200 S - 5C

Project Number: _____

Photogrammetric Maps

Town: _____

Sheet No. _____ of _____

Route: _____

MA in Sq. Ft. = _____

Date: _____

Contractor: _____

<p style="text-align: center;"><u>LENGTH OF TRAVERSE</u></p> <p>MA X 2 X 200 = _____ Computed = Field</p>	<p>Computed by: _____</p> <p>Checked by: _____</p>		
	Field Checked		Min. Spec. Req.
	No.	%	
<u>CULTURAL FEATURES</u>			
MA X 2 X $\frac{200}{40}$ = Min. no of Angular & Linear Measurements	XXX	XXX	
Number of cultural features checked		XXX	XXX
Number and percentage within 5'			90%
Number and percentage within 5' - 10'			10%
Number and percentage over 10'			0%
Total number of cultural features not shown		XXX	XXX
<u>CONTOURS</u>			
MA X 2 X $\frac{200}{40}$ = Min. no. of Contours to be Checked	XXX	XXX	
Total number crossed in wooded areas		XXX	XXX
Number and percentage in wooded areas within 5'			See Specifi- cations
Number and percentage in wooded areas within 5' - 10'			
Number and percentage in wooded areas over 10'			
Total number in cleared areas		XXX	XXX
Number and percentage in cleared areas within 2.5'			90%
Number and percentage in cleared areas within 2.5' - 5'			10%
Number and percentage in cleared areas over 5.0'			0%
<u>SPOT ELEVATIONS</u>			
MA X 1.5 = Min. no. of Spot Elevations to be Checked	XXX	XXX	
Total number of spot elevations checked		XXX	XXX
Spot elevations within 1.25'			90%
Spot elevations within 1.25' to 2.5'			10%
Spot elevations over 2.5'			0%
Number of spot elevations not shown		XXX	XXX
<u>Disposition</u>			
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved <input type="checkbox"/> Approved-subject to minor revisions			
<u>Remarks</u>			
<p>MA = The area in square feet within the perimeter of an orthographically projected representation of the earth and its features, as shown on a single map sheet.</p>			

