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SUBTASK REPORT

PROBLEMS AND POSSIBILITIES OF HIGH ALTITUDE WORLDWIDE MAPPING

PANORAMIC GEOMETRY DATA REDUCTION TEST PLAN

SECTION 1: PREPARATION AND MENSURATION

14 FEBRUARY 1967

Itek

ITEK CORPORATION

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FIGURES

1. INTRODUCTION

The Pilot Data Reduction Plan to be described herein is designed to extract four major pieces of information with respect to the utilization of calibrated panoramic materials for topographic map production. Specifically we want to determine:

1. The geometrical stability of the internal geometry of an operational panoramic camera by reference to calibration data
2. The effect of panoramic calibration data on the accuracy of control point determinations
3. Whether map compilation accuracy levels when utilizing calibrated panoramic inputs are sufficient to allow map scales of 1:250,000 and 1:50,000
4. The impact of calibrated panoramic inputs on mapping operations

The primary inputs to this Pilot Data Reduction are pairs of convergent panoramic photography, pairs of metric photography, auxiliary data from stellar cameras, horizon cameras, mission ephemeris, and calibration logs. In addition, since this is a test, the final input will be the descriptions and coordinate locations of sufficient ground control stations to provide the reference against which the exercise will be judged.

1.1 ORGANIZATION OF THE TEST

The Pilot Data Reduction is comprised of three general phases.

Phase I: Preparation and Measurement. In this phase all of the input photographic materials are reprinted and marked in preparation for measurement; the materials so produced are then measured to produce the coordinate data required for computational processing.

Phase II: Control Intensification Computations. In this phase all of the measured image coordinates and auxiliary data are brought together in a computer wherein the computation of auxiliary control station coordinates is performed. These auxiliary control stations serve as the geometrical restraint during map compilation.

Phase III: Compilation Tests. The third and final phase of the data reduction is devoted to setting up the panoramic models in plotting instruments and determining control station coordinates for all stations carried through the reduction but not used for controlling the reduction.

Each of these phases is detailed in a separate section. To derive all the answers wanted, the latter two phases described above are further segmented. Specifically, the control intensification computation phase is subdivided into two separate elements. In the first of these elements, control computations are performed using only the data extracted from the metric input. In the second segment, the metric input data are augmented by the panoramic calibration data. The same ground control stations are carried through both operations and at the conclusion of these operations, the derived ground coordinates are compared with record data to determine the relative accuracy of each approach. At this point then, the answer to the most important question, i.e., whether the addition of panoramic calibration data in the control computations materially enhances the accuracy of the resultant coordinate determinations, has been derived.

The compilation test phase is also subdivided. Answers to the following questions should be obtained during this phase.

1. Can we set up and control panoramic models sufficiently to allow compilation at a map scale at 1:250,000?

2. Can we set up and control panoramic models sufficiently to produce maps at the scale 1:50,000?

3. Can we, by proper treatment of the panoramic materials, produce photographic inputs to the M-4 plotters so that maps at the scale of 1:250,000 may be produced in this type of analog plotter? In this respect we want not only to know the accuracy obtainable, but also to establish the degree of difficulty encountered.

As with the control intensification phase, the concluding work in the compilation test phase is to compare the derived ground coordinate values resulting from each of the three tests against record data to determine the performance which has been achieved.

1.2 PREPARATION AND MEASUREMENT PHASE

By reference to Fig. 1-1, the Pilot Data Reduction Plan will now be discussed in some detail. Fig. 1-1 is an operational flow chart depicting material flow, specific operations to be performed, and the equipments likely to be utilized in the performance of each individual function. Note that the legend which describes the identity of particular flow lines appears at the top of Fig. 1-1. Those operations designated as operational blocks 20 and 25 through 29 will appear in Section II. Those operations designated as operational blocks 30 through 36 will appear in Section III. Each functional box is numbered for reference purposes.

1.2.1 Inputs to the Preparation and Measurement Phase

The inputs to the Preparation and Measurement Phase enter at functions 1, 5, 21, and 26. The input to function 1 is the duplicate positive of the forward-looking panoramic camera. In this instance, the choice of the forward-looking panoramic is arbitrary. The second panoramic (aft) input to the reduction enters into function 5.

Entering into function 1 as inputs are the identification descriptions of all the ground control stations that will be used in the data reduction. Both of the duplicate negatives produced by the metric camera are introduced to the data reduction at operation 21. Blocks 26 and 27 indicate that the coordinates of ground stations are entered and that the reduced data from stellar and horizon optics are entered. Implicit in the input of these auxiliary data is the input of the mission ephemeris. (These operations occur in Section II.)

The functional flow of the inputs to the Preparation and Measurement Phase is described below.

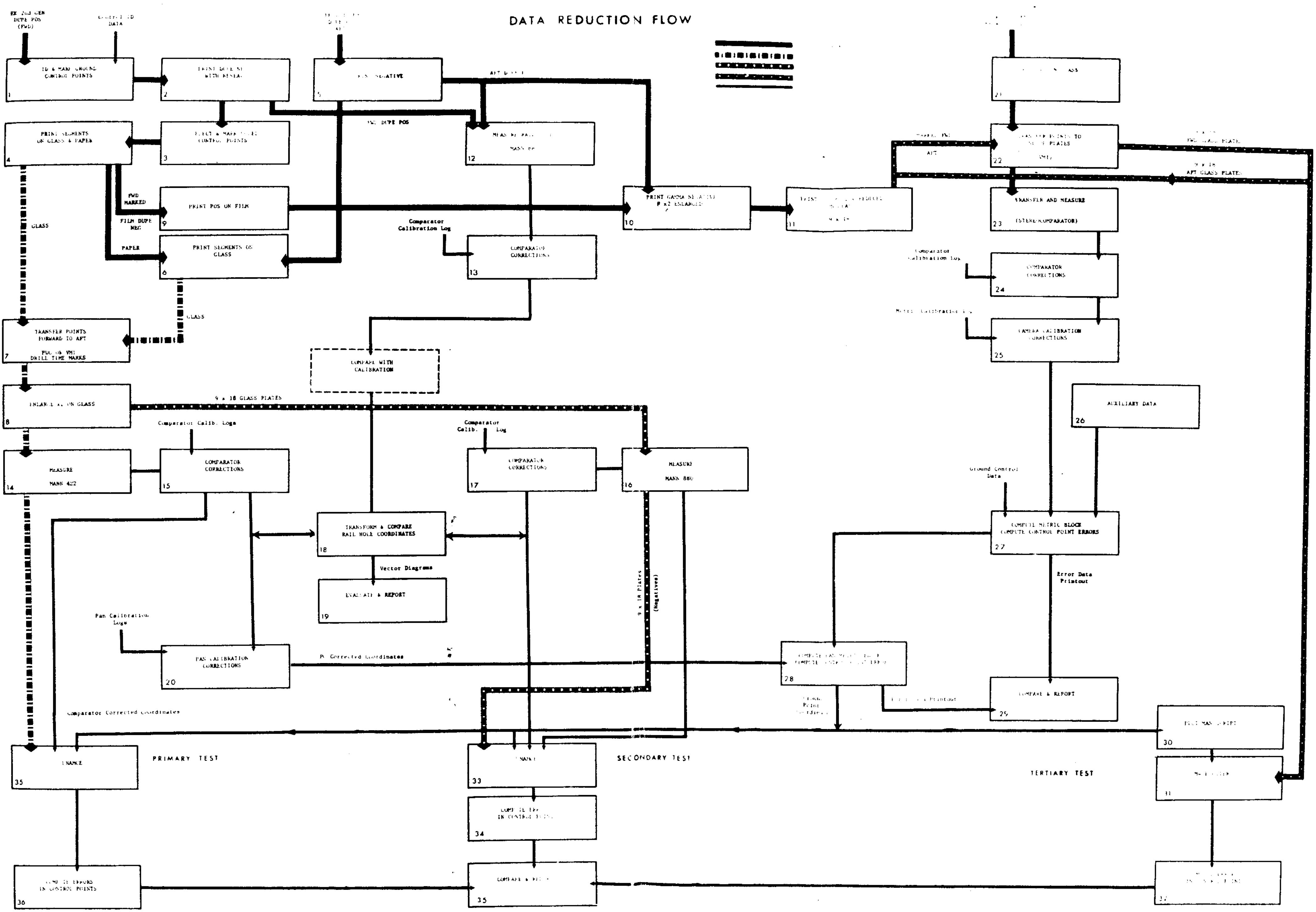


Fig. 1-1 — Pilot data reduction test plan

1.2.2 Preliminary Operations

In function 1, all of the ground control stations to be used in the data reduction are identified and marked in the emulsion of the positive images. For this purpose it is necessary to have the ground control identification data and some instrument with which to view the imagery, identify the points in question, and physically mark their locations. For this purpose, it is likely that the Wild PUG-2 will be used. This is not a stereo operation, but the Wild PUG-2 provides the necessary viewing optics and a drill which may be used to mark the points that have been found. (Refer to the data sheet for operation 1.)

Having marked all the ground control stations that will be used, the positive images are directed to operation 2. In this operation, the positives are reprinted in contact with a positive reseau master. This reseau is added to the imagery for only one purpose, i.e., to provide a multitude of easily identifiable photographic points of which some will be selected at a later time as the auxiliary control points which are necessary to the compilation operations in Section III.

Having introduced the reseau to the imagery, it is necessary, in function 3, to mark 51 of the multitude of reseau intersections to identify them as model control. The selection of these points is somewhat arbitrary except they should be evenly distributed over the length of the panoramic frame and be at locations where the background imagery appears suitable for later point transfer operations.

1.2.3 Marking of Tie Points

After marking the 51 model control points, it is necessary, in this same operation, to transfer a few of these marked reseau intersections to the adjacent forward panoramic images. This operation allows the lateral tying together of the panoramic models similarly to that done in blocks of conventional aerial photography. For this operation, then, the Wild PUG-2 will again be used, but now the operation will be in stereo.

1.2.4 Segmenting

By the time operation 3 is concluded, all of the point locations to be used in the data reduction have been inscribed, in one manner or another, on the forward-looking panoramic images. Now, since these images are some 30 inches long, they must be segmented and printed on glass so that the segment images are ready for use in the compilation phase. Segmenting, which is a photographic printing process, results in the production of four 9- × 9-inch glass plates for each of the panoramic images involved (see Figs. 1-2 and 1-3). This is accomplished in operation 4 with due regard to the location of the 51 model control points previously established in function 3. Also in this operation, identical paper prints are made for the segments produced so that these paper prints may be utilized in controlling the segmenting of the aft-looking panoramic images.

With reference to the paper prints produced in operation 4, the negatives of the aft-looking panoramics produced in operation 5 are segmented onto glass in operation 6. In this operation the requirement is to get, as nearly as possible, the same ground area imaged in each segment as is contained in its respective forward panoramic segment.

The glass plate segments produced in operations 4 and 6 are transferred now to operation 7. In this operation, all of the points marked upon the forward-pan images must be transferred to the aft-pan images, which, at this point, contain no markings except calibration data. This, then, is a stereo transfer problem and will likely be accomplished by means of the Wild PUG-2. Once the transfer of image points is completed, the control network on both the fore and aft images has been established. This network dictates the panoramic calibration data to be extracted and it is therefore an opportune time to drill or otherwise mark the significant "time" marks related to the image area. Time marking prior to this step would result in redundant or unrelated marking.

1.2.5 Scale and Resolution Considerations

Inasmuch as we want to perform two compilation tests, one using contact scale panoramic images, and one using 2× enlarged panoramic images, function 8 is included in the data reduction flow to accomplish this purpose. In this operation, the forward-looking panoramic segment plates which have been marked in operations 1, 3, and 7 and the aft panoramic segment plates which were marked in operation 7 are all reprinted at a 2× enlargement on 9- × 18-inch glass plates. At the conclusion of this operation, then, we have two complete sets of segment plates, one set at contact scale and one set 2× enlarged.

1.2.6 Measurement Functions

For the purposes of following computational functions, all of the marked image points and the appropriate calibration points must now be measured in all the images which have been prepared. Operational blocks 14 and 16 indicate this measurement function in the data reduction flow. In operation 14, 9- × 9-inch size glass plates are measured; consequently, the instrument to be used is the Mann 422 or an equivalent comparator. Since in operation 16, we must operate on 9- × 18-inch glass plates, it will be necessary to use an instrument such as the Mann 880 or an equivalent comparator. At this point let us digress for a moment, and discuss the logic underlying the operations 7, 8, 14, and 16.

The UNAMCE which will be one of the compilation equipments employed in the compilation tests has an operational resolution limit in the order of 40 lines per millimeter. Consequently, in order that the resolution of the panoramic materials may be fully utilized, we are forced in one instance to enlarge these panoramic materials 2× to effect the adjustment of resolution levels. In the alternate compilation test, the panoramic imagery was used at contact scale, with full realization that with UNAMCE the resolution capability of the input photography will not be fully utilized. This situation will be discussed more fully in Section 3 where the compilation tests are covered. However, the requirement for two sets of photography and the limitation on equipment available for measurement have combined to establish the operational sequences illustrated by functions 7, 8, 14, and 16. For instance, if we had just the segment pairs produced by operations 4 and 6 and were required to measure the image point and calibration data, then this measurement operation could be more economically accomplished by the use of a stereocomparator. This would mean that operations 7 and 14 would become one integral function and points would never be physically marked on the aft-looking pan segments. The requirement to operate upon 2× enlarged images does not, however, allow the nicety of such a solution. The reason for this is that there is no operationally available stereocomparator equipment which is capable of handling 9- × 18-inch material. Consequently, points must be transferred in the monocular comparator which is available to us.

1.2.7 Mensuration and Evaluation of Calibration Marks

Having completed operations 14 and 16, all the numerical data from the panoramic images that are necessary to the remainder of the data reduction have been extracted. However, at this

[redacted]

point there is no way of evaluating the effect of our processing on the geometrical character of the panoramic imagery. Therefore, operation 12 is inserted in the data reduction plan. In this operation selected calibration data are measured on the duplicate positives of the fore and aft panoramic images which were input to the pilot data reduction. By measuring this data on the original input material and referring measurements of the same points in operations 14 and 16, we can deduce in operation 19, whether or not our data reduction processing has introduced significant geometrical changes into the photographic images. Of particular interest in this area will be the geometry of images enlarged in operation 8. The enlarger used in operation 8 certainly should be calibrated. But of more interest here is whether or not we are able to introduce segments into the enlarger locationally consistent enough so that the geometrical distortions induced thereby are consistent in the output images. Such consistency will materially aid in the computational portions of the following data reduction.

1.2.8 Remaining Tasks

With respect to the Measurement and Preparations Phase of the data reduction, there remain two tasks to be performed. First, the photographic materials for the analog compilation (tertiary) test must be produced and second, material must be prepared and data coordinated with respect to all image points from the metric photographic input.

To utilize panoramic imagery in the M-4 analog plotter, it is required that the imagery be rectified and brought to a scale consistent with the focal length of the M-4 plotter (12 inches). Consequently, in operation 10, we rectify and print in the Gamma I the marked forward positive remaining after the completion of operations 3 and 9, and the aft positive remaining after the conclusion of operation 5. Rectification and printing in the Gamma I enlarges the input material by about 1.9×. Consequently, bringing the photography to scale for analog plotting requires that the Gamma output in operation 11 be reduced to 1/4 of its scale. Since the Gamma output is a negative, this reduction step will produce glass positives which in operation 31, are the glass plate diapositives required for the analog plotter.

One of the basic requirements for this data reduction program is that all the ground points which have been established in the panoramic images be found and measured in the metric images. All of these points are marked on the duplicate positive which has come from operation 9. This same positive has been rectified and printed in operation 10. Consequently, at the conclusion of operation 10, photographic images which are approximately 16× larger in scale than the input metric photography have been obtained. In order to transfer points and measure, these images must be brought photographically to a scale operationally acceptable in the VMI. (The VMI is designed to accept scale differences of 16:1 with differential magnifications of 32:2; however a 32× magnification of the lower resolution metric image provides an image visually unsuitable for good stereo transfer. Therefore, the following operations are designed to reduce the differential magnification allowing optimal use of the images and VMI.)

The mechanism for accomplishing this is as follows. The original metric format is $2\frac{1}{4} \times 2\frac{1}{4}$ inches with a resolution in the order of 70 to 80 lines per millimeter. In order to fully utilize this resolution and also to reduce transfer and measurement errors with respect to the calibrated camera geometry of the metric camera, the scale of the metric image will be increased by means of a 4× enlargement which will produce, in operation 21, a 9- × 9-inch image format on a glass diapositive plate. In operation 11, the Gamma output has been reduced in scale by a factor of 1/4. The reduced marked forward images, on 9- × 18-inch glass diapositives are then only 2× the scale of the metric diapositives produced in operation 21. Now in operation 22, every image point

[redacted]

(marked grid intersections and marked ground control points) in the 9- × 18-inch forward pan image is transferred and marked on one of the 9- × 9-inch metric images. This is accomplished using the VMI at a differential magnification of 2:1. (Practice has indicated that 8× magnification of the metric image and 4× magnification of the pan image is reasonable.)

Since it is required that the image points transferred and marked in operation 22 be measured on both of the metric images, a 9- × 9-inch stereocomparator is used in operation 23 to measure the marked metric plate from operation 22 and to stereo transfer and measure the image points on the other metric plate. It would appear that a Nistri TA-3A or STK-1 is likely to be used. It should also be recognized with respect to this operation that not only must the image points be measured, but also it is required that the metric reseau intersections circumscribing these points must be measured in order that all of the points may be established within the calibrated geometry of the metric camera.

At the conclusion of operation 23, the Preparation and Measurement Phase of the data reduction is complete.

1.2.9 Remarks

Before measured coordinate data produced in operations 12, 14, 16, and 23 can be processed further, the comparator calibration corrections must be applied to the resultant image coordinates. This is accomplished in operations 13, 15, 17, and 24. The output coordinate data produced in operations 12 and 13 may be utilized for a limited "postflight" analysis, hence the unnumbered operation step "Compare with Calibration". However, inherent in operations 20 and 25 are the necessary calibration corrections and operational evaluation.

1.3 DATA FORMAT

To minimize the task as far as possible and require the least amount of pointings, the following plan is suggested. Fig. 1-2 is a model of the forward-looking pan, while Fig. 1-3 is the aft-looking instrument.

As a guide to the comparator operator, in place of marking on each piece of glass, it is suggested that all necessary identification information be made on a print from the Gamma rectifier and keyed to the glass segment. The information marked should consist of frame number, instrument number, plate number, module number, image of interest number, time hack numbers, and other desired information to make the mensuration task less difficult.

There are four categories of measurements to be made: (1) holes; (2) time hacks; (3) ground control; and (4) collimator traces.

1. All holes appearing on each sector will be measured. All fields and subfields of a card are to be filled. When aligning the sector plates on the comparator, care should be taken to align the holes with the y screw.

2. The necessary number of trailing time hacks are to be pointed for each module.

3. The last items to be pointed are the image of interest points and the trace closest to the image point of interest. This should be accomplished by pointing the image point and then moving in only the x direction to the nearest trace. The reading in the y direction should always be identical to the y reading of the image point with only the x distance changing.

It is important that no overlap of image points of interest occur, i.e., any module will be pointed only with the two passes and not remeasured on the overlapping plate.

After the mensuration (two passes on each image) is completed on one segment, then that segment may be removed and the next one placed on the comparator stage. The same procedure should be followed on each segment with only the overlapping points being the rail hole images which will be used in joining the four sections for the comparison test.

The same coding system as used on the segmented sections may be used on the frame camera measurements coming from block 25, using only the applicable columns on the card and leaving blank the columns not needed. It is important that consistency be maintained for all card columns as assigned.

Two separate pointings should be made of everything. Origin and orientation need not be maintained between passes. The order of measurement within a module is of no consequence due to the unique identifiers for each measured point.

All point measurement cards for the glass plates and frames will have the following fields and subfields. All cards will have the same format.

Pan or Frame Indicator		Inst.-Frame Number		Sector-Module		Point ID		X Coor.		Y Coor.		Weight
X	b	XXX XXX	b	XXX	b	XXXX	b	bbb+XXXXXX	b	bbb+XXXXXX	b	X

The detailed structure of each field is as follows.

Column Number	Remarks
1	Column one will contain the number 0 for a pan photograph or 1 when the measurements are made from a frame photograph.
2	Blank.
3 through 8	The first three digits will be the instrument number and the last three digits the frame number. The photographs being measured will be numbered by frame as follows: a. Metric frames will be 1 and 2. b. All pan frames from the even serial-numbered instrument (forward-looking) will be assigned odd frame numbers, i.e., 3, 5, 7, etc., while frames from the odd serial numbered instrument will be assigned even numbers, i.e., 4, 6, 8, etc.
9	Blank.
10 through 12	Plate number and module number. These numbers will be used only when measuring the segmented glass plate. Column 10 will contain the plate number as assigned from 1 to 4. The module number in columns 11 and 12 will be the specific prenumbered module on the

[redacted]

NOTE: This sketch shows, for the forward-looking camera, the segmenting operation, point numbering system, and module breakdown with their numbering systems as they would appear on a diapositive emulsion side up in object space. This hole image and collimator trace numbering system also agrees with the Itek calibration report on the PG instrument and should be used in all measurements being made.

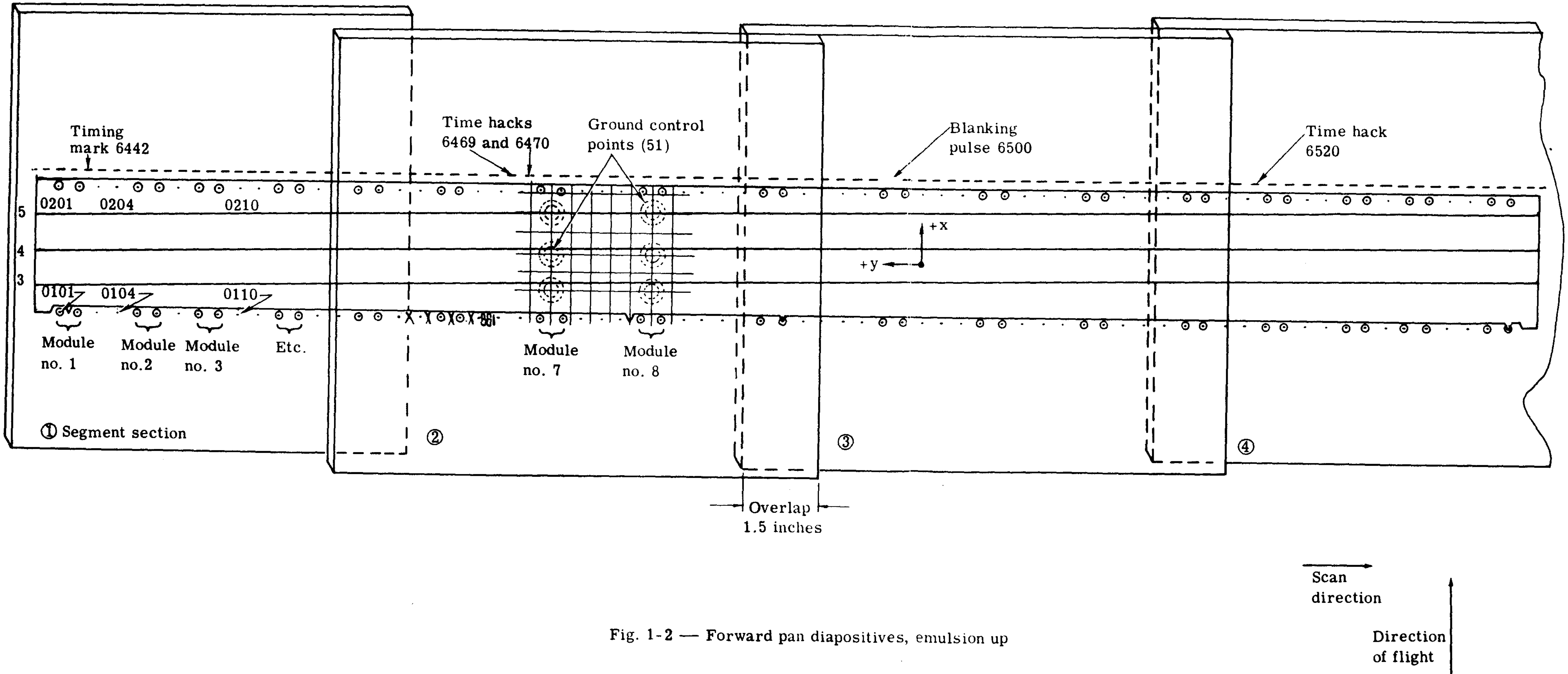


Fig. 1-2 — Forward pan diapositives, emulsion up

NOTE: This sketch shows, for the aft-looking camera, the segmenting operation, point numbering system, and module breakdown with their numbering systems as they would appear on a diapositive emulsion side up in object space. This hole image and collimator trace numbering system also agrees with the Itek calibration report on the PG instrument and should be used in all measurements being made.

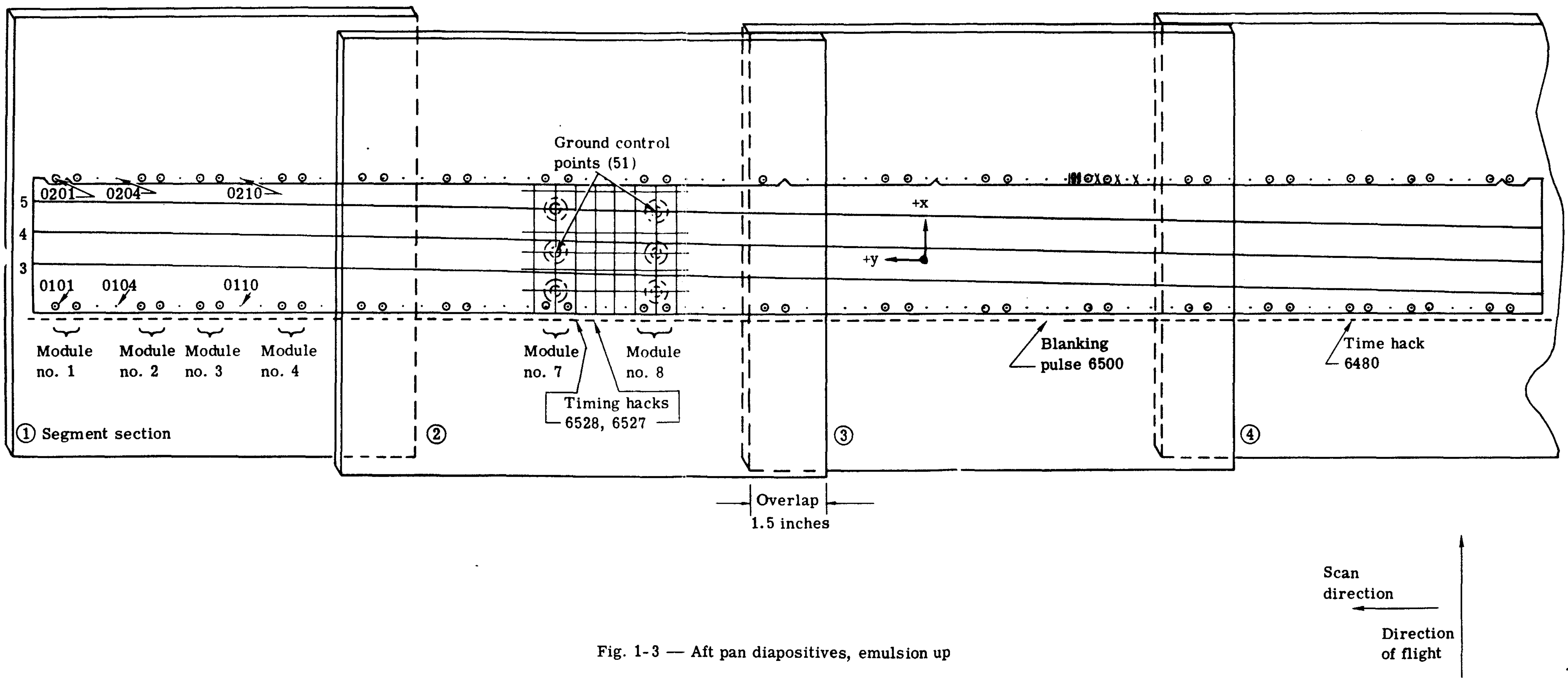
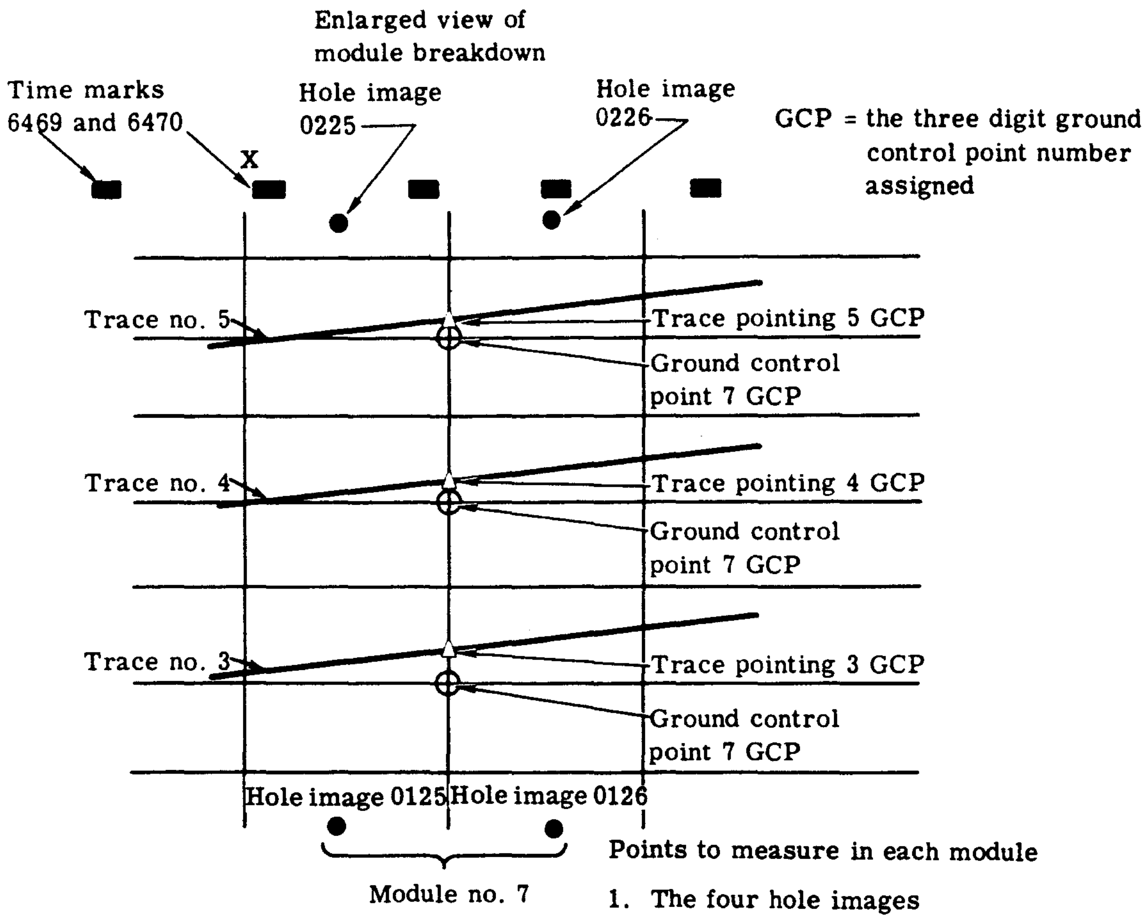


Fig. 1-3 — Aft pan diapositives, emulsion up

Column Number	Remarks
	paper print and related to the glass plate from which the measurements are made, i.e., (see Figs. 1-4 and 1-5) module no. 7. For all points measured on that module, columns 10, 11, and 12 would carry the numbers 207 while the 17th module would carry the numbers 417, etc.
13	Blank.
14 through 17	Point identification numbers coded as follows: a. 0101 to 0173 rail holes as assigned per calibration report or Figs. 1-2 through 1-5. b. 0201 to 0273 rail holes as assigned per calibration report or Figs. 1-2 through 1-5. c. 3 GCP—the first digit will denote the trace no. 3 as assigned. The last 3 digits labeled GCP will be the assigned control point associated with trace no. 3. (See identification number 7 GCP below.) d. 4 GCP and 5 GCP will be the same as 3 GCP except that they denote the traces no. 4 and 5 and the control point number associated with that particular trace. e. 6500 will denote the blanking pulse and will never appear on a card. All pulses in the scan direction from the blanking pulse will progress, i.e., 6501, 6502, 6503, etc., while the pulses going opposite the scan direction will regress, i.e., 6499, 6498, 6497, etc., (see Figs. 1-2 and 1-4). f. 7 GCP the first digit denotes the image point of interest measurement. The three digits labeled GCP will contain the assigned control point number.
18	Blank.
19 through 28	X coordinate with ± sign. Right justified.
29	Blank.
30 through 39	Y coordinate with ± sign. Right justified.
40	Blank.
41	An assigned value by the comparator operator as to the goodness of his pointing. The goodness factor is scaled from 1 to 4.

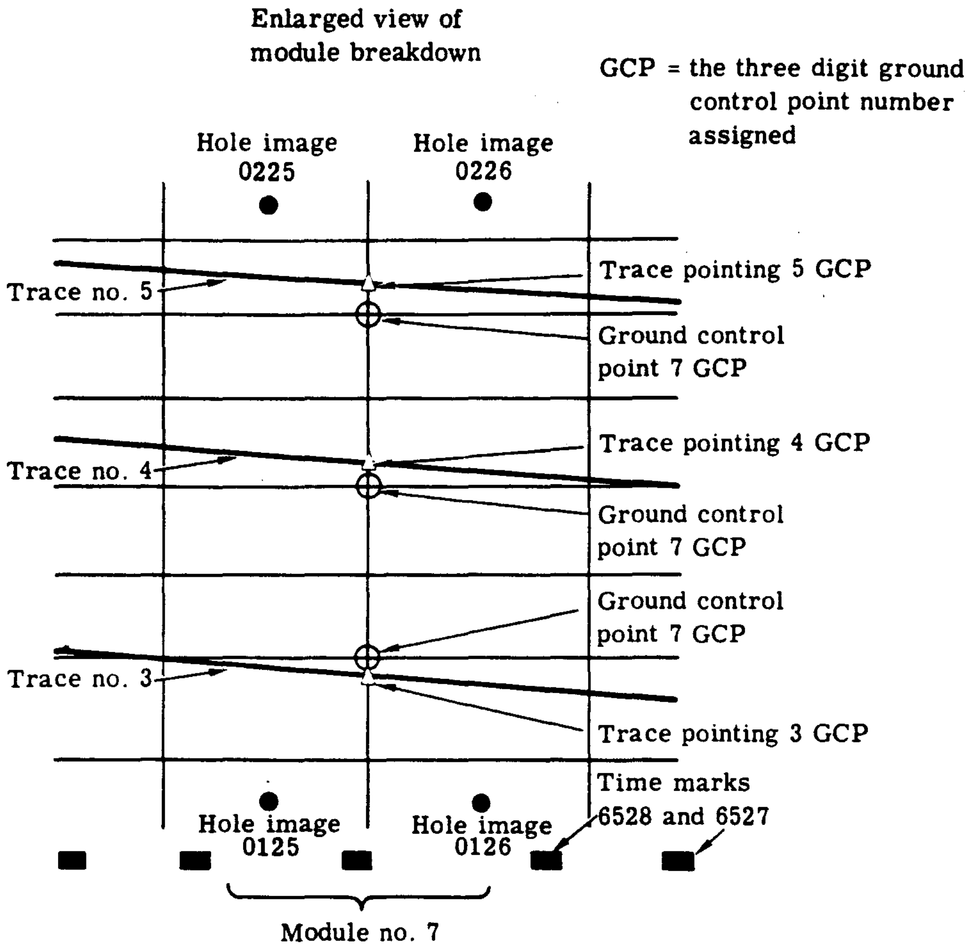
There are other items that must be included in the data to be furnished. The ephemeris data, and the clock data from the data block for the phtographs used will be needed. We will also need the coordinates of the ground points in the UTM system. The card format for this information is as follows.



Points to measure in each module

1. The four hole images
2. The two trailing time marks
3. Ground control points
4. Nearest trace to the ground control points with the y axis unchanged from the ground control point measurement

Fig. 1-4 — Forward measurement module



Points to measure in each module

1. The four hole images
2. The two trailing time marks for each module
3. Ground control points
4. Nearest trace to the ground control points with the y axis unchanged from the ground control point measurement

Fig. 1-5 — Aft measurement module

Columns	Information
1 through 4	Ground point identification number.
5	Blank.
6 through 15	Northing.
16	Blank.
17 through 26	Easting.
27	Blank.
28 through 37	Elevation.
38	Blank.
39 through 42	Zone.
43	Blank.
44 through 45	Goodness.

All fields will be right justified.

The goodness factor is scaled from 1 to 4. AMS will specify the standard deviation in northing, easting, and elevation that corresponds to each goodness factor.

2. TEST PLAN

DATA REDUCTION OPERATIONS

The following is the sequence of data reduction operations:

1. Identify and mark ground control points.
2. Print dupe negative with reseau.
3. Select and mark model control points.
4. Print segments on glass and paper.
5. Print aft negative on film.
6. Print aft segments on glass.
7. Transfer points from forward to aft and drill time marks.
8. Enlarge 2× on glass.
9. Print forward positive on film.
10. Print Gamma negatives of forward and aft.
11. Print Gamma positives on glass at 0.25×.
12. Measure rail holes.
13. Comparator corrections (compare with calibration).
14. Measure 9- × 9-inch plates.
15. Comparator corrections.
16. Measure 9- × 18-inch plates.
17. Comparator corrections.
18. Transform and compare rail holes.
19. Evaluate and report.
20. Pan calibration corrections.
21. Print metric 4× on glass.
22. Transfer points from forward pan to metric.
23. Transfer to other metric plate and measure.
24. Comparator corrections.
25. Camera calibration corrections.
26. Auxiliary data input.
27. Compute metric photo block.
28. Compute pan-metric photo block.
29. Compare and report.
30. Plot manuscript.
31. M4 plotter 1:250,000.
32. Compute errors in control points.

33. UNAMCE 1:50,000.
34. Compute errors in control points.
35. UNAMCE 1:250,000.
36. Compute errors in control points.
37. Compare and report.

The operations are described in detail below.

OPERATION 1
TYPE: Image Point Marking

SECTION: Preparation and Measurement

TASK: IDENTIFY AND MARK GROUND CONTROL POINTS [redacted]

INPUT: Positive transparencies of forward panoramic, as original input to the system [redacted] second generation)

In this task all of the ground control stations to be used in the subsequent data reduction process are identified with marks in the emulsion of the positive copies. For this purpose the ground control identification must be available. A PUG has been assigned this task although a stereo operation is not required. The PUG provides the necessary optics and point marking capability. In this operation all of the control that can be verified should be marked.

EQUIPMENT: Wild PUG Point Transfer Device. A marking drill of 60 microns is recommended.

OUTPUT: Positive transparencies of forward panoramic with marked ground control points

OPERATION 2
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: CONTACT PRINT THE POSITIVE COPIES OF THE FORWARD PANORAMIC FRAMES WITH A SUPERIMPOSED RESEAU

INPUT: Positive transparencies of forward panoramic with marked ground control points

The positive copy marked with ground control in operation 1 is contact printed on the Contact Duplicator and Reseau Printer. Prior to actual printing operations, check for the proper exposure for the reseau printing operation to ensure best reseau quality with minimum line spread. Contrast and density scales must be controlled and it is recommended that SO-153 duplicating film be used for this operation. Process control should be continued and monitored. The center of format of the print must be punched or coded to permit alignment for reseau printing. Refer to Fig. 2-1.

CONTRAST: Maintenance of a density scale of approximately 1.0 and a Gamma of 1.0 is suggested.

SUGGESTED MATERIALS: SO-153 (8430 on estar base)

EQUIPMENT: Contact Duplicator and Reseau Printer

PROCESS CONTROL: Begin process control procedures.

ADDED COMMENTS: The fiducial holes in the margin of the panoramic geometry format are located 1 centimeter apart and are referenced in the camera so that the central holes are opposite each other. The 1-centimeter reseau grid should be located so that the grid network bisects the hole network. The output image will display alternating "dots" and "lines" every 0.5 centimeter along the entire length of the format.

Care should be taken so that the grid lines placed along the format do not pass through the fiducial dots. If the centerline of the format is aligned to the centerline of the reseau, proper horizontal alignment of the reseau will be effected.

OUTPUT: Contact negative prints of forward panoramic with superimposed reseau image

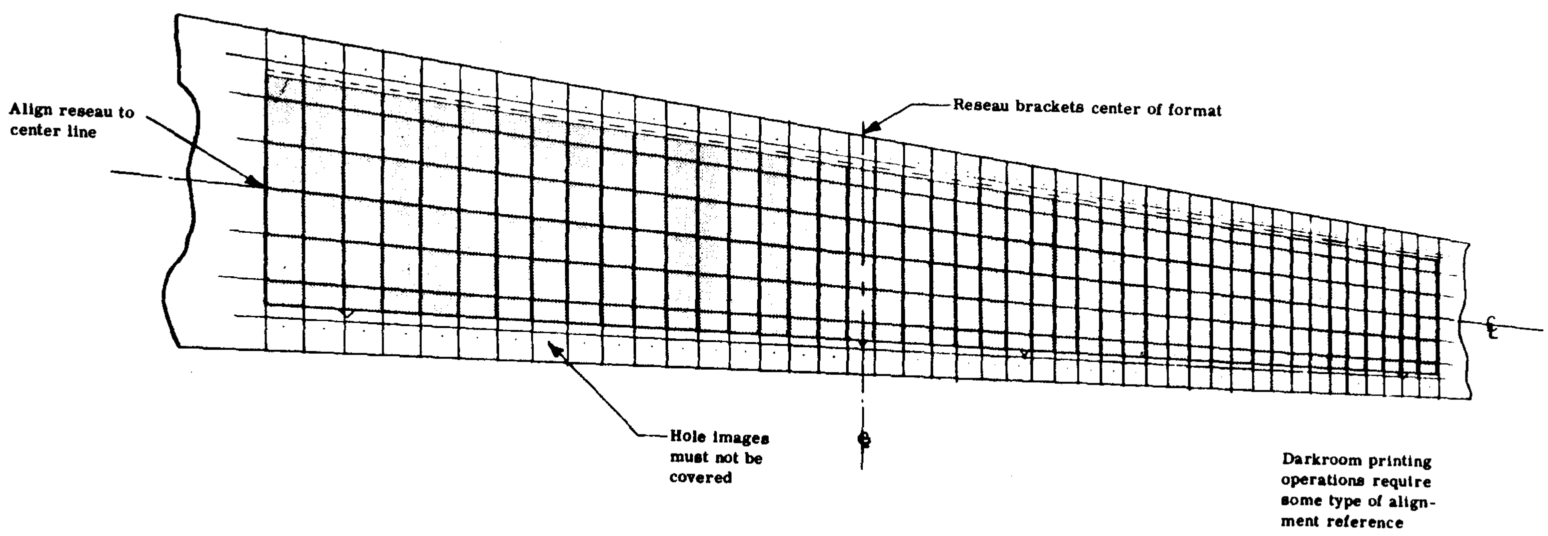


Fig. 2-1 — Operation 2 reseau printing

OPERATION 3
TYPE: Image Point Marking

SECTION: Preparation and Measurement

TASK: SELECT AND MARK MODEL CONTROL POINTS

SUBTASK: Transfer and mark lateral tie points to adjacent forward panoramic

INPUT: Contact negative transparencies of forward panoramic with superimposed reseau and marked control

In this operation a network of photographic control will be established. We have the option of choosing control points which have been marked in operation 1 or selecting reseau intersections printed in operation 2 as photographic control. The basic criterion is that the points be evenly distributed over the length of the panoramic frame and at locations where the background imagery appears suitable for later point transfer operations. The suggested density for selection of model control points is three rows of 17 points each throughout the length of the panoramic frame. This would constitute 51 points per frame. These points can be marked either by a pencil type marking or by a PUG mark. A stereoscopic viewing device is not necessary for the major task. The subtask of transferring of lateral tie points requires the application of the stereo features of the PUG. In this operation, 12 marked reseau intersections must be transferred to the adjacent panoramic image. If evenly distributed, this provides three marked intersections per segment in the subsequent operation. This operation allows the lateral tying together of panoramic models similar to that done in conventional aerial triangulation.

EQUIPMENT: Wild PUG-2 Point Transfer Device

OUTPUT: Negative transparencies of forward panoramic with marked ground control, marked model control, and transferred tie points

OPERATION 4
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: CONTACT PRINT FORWARD PANORAMIC SEGMENTS ON GLASS PLATES

SUBTASK: Print paper prints of identical segments for control of operation 6.

INPUT: Forward panoramic frames with marked control and reseaus

This operation produces the 9.5- × 9.5-inch diapositive plates for the 1:250,000 compilation test. These same plates are also used in operation 8 as the inputs for the 2× enlargements on glass for the 1:50,000 compilation test.

Determination of the most useful diapositive characteristics required for UNAMCE should be accomplished. Diapositives that have a density scale permitting formation of a usable stereo model and accurate compilation must be produced. After a frame of reference has been established for the compilation tasks, continued use of the densitometer will greatly facilitate keeping the work within these standards.

The material suggested for these tests is Super Aerographic Positive-Medium contrast. These plates are in the high resolution class for diapositive plates, thus reducing resolution degradation to a minimum.

In addition to the plates, paper prints must be generated for each of the four segments to be printed from each pan frame. These prints must contain the identical imagery.

The overlap between segments should be a minimum of 1½ inches to ensure the inclusion of calibration data common to adjacent plates.

EQUIPMENT: Log E contact printer

PROCESS CONTROL: Continue process control procedures and monitor results.

OUTPUT:

1. 9.5-inch diapositive plates containing segments of forward panoramic frames with marked control and reseaus.
2. 9.5-inch paper prints of above segments.

OPERATION 5
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: CONTACT PRINT AFT PANORAMIC FRAMES ON FILM

INPUT: Second generation [redacted]

This is a straight contact printing operation to provide internegatives for subsequent photographic operations requiring the printing of glass diapositives in operation 6. A reseau is not required in this printing operation.

CONTRAST: The internegative should be exposed such that the toe portions of the negative are reproduced on the upper portion of the toe of the reproduction film. The film should be held to a maximum Gamma of 1.0.

MATERIALS: Type SO-153 (estar base version of type 8430)

EQUIPMENT: Log E Printer

PROCESS CONTROL: Step wedges and resolution targets are to be included in the imagery.

OUTPUT: Internegatives of the original AFT pan frames

OPERATION 6
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: CONTACT PRINT AFT PANORAMIC SEGMENTS ON GLASS

INPUT: Duplicate negatives of aft panoramic frames from operation 5 (also 9.5-inch paper prints for reference)

The original duplicate negatives of the aft panoramic frames are contact printed by segments onto glass plates, each frame being segmented on 9.5-inch glass plates, and the imagery being matched to the forward panoramic plates produced in operation 4 by referring to the paper prints provided. Proper overlap between segments is important (see details of operation 4). The overlap should be a minimum of 1½ inches so as to include proper control point imagery on adjacent plates.

CONTRAST: The density scales of these plates must match those from operation 4. Process to a Gamma of 1.0.

MATERIALS: Kodak Super Aerographic Positive Plates 9.5 × 9.5 inches

EQUIPMENT: Log E contact printer

PROCESS CONTROL: Continue process control.

OUTPUT: 9.5-inch glass diapositives of aft panoramic frames

OPERATION 7
TYPE: Point Transfer and Marking

SECTION: Preparation and Measurement

TASK: TRANSFER CONTROL AND MARKED RESEAU POINTS FROM THE FORWARD PANORAMIC TO THE AFT PANORAMIC SEGMENTS AND MARK

SUBTASK: Drill Time Marks

INPUT: 1. 9.5- × 9.5-inch diapositive plates containing segments of forward panoramic with marked control and reseau intersections

2. 9.5- × 9.5-inch diapositives of segments of aft panoramic

All of the points previously marked on the forward panoramic frames are now transferred to, and marked on, the aft panoramic frames. This is a stereo point-transfer operation.

At this point the control network on both the forward and aft images has been established. Therefore it is an opportune time to drill or otherwise mark the significant time marks related to the image area.

EQUIPMENT: Wild PUG Point Transfer Device

OUTPUT: Identical to the input image, except that all of the image points have been transferred to the aft panoramic segment plates.

OPERATION 8
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: ENLARGE 9.5- × 9.5-INCH DIAPOSITIVES ONTO 9.5- × 18-INCH PLATES

INPUT: 9.5- × 9.5-inch diapositive plates of forward and aft panoramic frames segmented and printed in operations 4 and 6

This operation produces enlarged segments of the forward and aft panoramic frames for use in the 1:50,000 compilation test. For optimum results and accuracy, the enlarger used for this operation should have known distortion characteristics and means should be provided for reproducible placement of the input plates in the negative carrier.

CONTRAST: The density scales and contrast of these plates must be commensurate with UNAMCE.

MATERIAL: 9.5- × 18.5-inch Kodak Super Aerographic Positive Plates, medium

EQUIPMENT: B&L Precision Enlarger (2×)

PROCESS CONTROL: Continue process control procedures.

OUTPUT: 9.5- × 18.5-inch diapositive plates containing enlarged segments of forward and aft panoramic frames with marked control and reseaus. This output will be a negative.

OPERATION 9
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: PRINT POSITIVE ON FILM OF MARKED FORWARD PANORAMIC INTERNEGATIVE

INPUT: Marked forward panoramic frames from operation 3

Upon completion of the printing of the glass diapositive segments in operation 4, proceed with this operation. This operation provides a positive of the marked forward internegatives for subsequent printing in the Gamma I Rectifier.

CONTRAST: This operation should follow previous control procedures and produce an internegative slightly on the heavy side with the minimum density/base fog density at approximately 0.20 to 0.30. The film should be processed to a Gamma of 1.0 or lower. Density scales should be maintained as long as possible to retain subtle gradations in the original.

MATERIAL: Type SO-153 (type 8430 estar base)

EQUIPMENT: Log E Contact Printer

OUTPUT: Positive contact scale transparencies as input to the Gamma Rectifier

OPERATION 10
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: RECTIFY AND PRINT FORWARD AND AFT PANORAMIC FRAMES

INPUT:
1. Positive transparencies of forward panoramic frames with marked control and reseaus
2. Duplicate positives of aft panoramic frames
3. Rectification data

The purpose of this operation is to produce a rectified positive transparency of each frame for subsequent reduction and compilation in analog plotting equipment. In addition, a subsequent reduction of the forward panoramic frames will be used for point transfer to the metric photography. Care must be taken in this operation to produce a full scale positive with minimum losses in detail. Rectification data will be supplied with the input materials.

EQUIPMENT: Gamma I Rectifier

MATERIAL: Suggested use of EK type 153 9.5-inch film

OUTPUT: Forward and aft panoramic frames enlarged approximately 1.9× and rectified for panoramic distortion, earth curvature, and pitch tip and roll tilt. Format will be approximately 80 inches in length. Effective focal length at this time will be approximately 45 inches.

OPERATION 11
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: REDUCE AND PRINT RECTIFIED PANORAMIC FRAMES ONTO GLASS DIAPOSITIVES, 0.25 REDUCTION OF BOTH FORWARD AND AFT FRAMES

INPUT: Forward and aft panoramic frames, enlarged and rectified from the Gamma I

The negative output of the Gamma I Rectifier is to be reduced 0.25× directly onto 9- × 18-inch glass diapositives. The dimensions of the input to this operation are 9.5 inches by approximately 80 inches and will probably of necessity be imaged across the diagonal of the Klimsch Process Camera. Parallelism of the camera should be ensured and the lens should be of superior quality. A through-focus test is recommended.

SUGGESTED MATERIAL: Depending upon the contrast of the input material, either type 228 or SO-153 duplicating materials may be used for the Gamma print. Use Kodak Super Aerographic Medium Glass Plates for the diapositives.

EQUIPMENT: Klimsch Process Camera

OUTPUT: 9- × 18-inch glass diapositives of rectified forward and aft panoramic frames

OPERATION 12
TYPE: Coordinate Measurement

SECTION: Preparation and Measurement

TASK: MEASURE AND RECORD COORDINATES OF ALL RAIL HOLE IMAGES ON ORIGINAL FORWARD AND AFT PANORAMIC INPUT

INPUT: Duplicate positive of the forward and aft panoramic images (original inputs)

The rail hole images of all forward and aft frames used in this test are to be measured. These measurements will be used as coordinate reference data in operation 19. These measurements may also be used for comparison with the PG calibration for a limited postflight analysis of calibration stability.

EQUIPMENT: Mann 880 Comparator

OUTPUT: Coordinate data for all measured rail hole images of the forward and aft panoramic frames

OPERATION 13
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: CORRECT COORDINATE DATA FROM OPERATION 12 WITH COMPARATOR CALIBRATION CORRECTIONS

INPUT: Coordinate data of rail hole images from operation 12.

As a function of the comparator calibration log of the Mann 880 Comparator used in operation 12, the comparator calibration correction referenced to the coordinate system of the comparator should be applied to the coordinates of the rail hole images.

EQUIPMENT: Computation equipment

OUTPUT: Corrected coordinate data of the rail hole images measured in operation 12. This output data may be compared to the calibration log in order to determine the operational stability of the calibration. This sample is limited to the block of photography which we are using in the data reduction tests.

OPERATION 14
TYPE: Coordinate Measurement

SECTION: Preparation and Measurement

TASK: MEASURE AND RECORD COORDINATES OF ALL CALIBRATION, CONTROL, AND MARKED RESEAU INTERSECTIONS

INPUT: 9.5-inch glass diapositive plates of segmented forward and aft panoramic images.

For the purposes of subsequent computational functions, all of the marked image points and the appropriate calibration points must now be measured in all of the images that have been prepared. (For seven stereo panoramic models this means 28 pairs of glass diapositives, a total of 56 diapositives.)

The types of points in each measurement module, the number of modules per segment, the sequence of measurement, the coordinate recording, and card formating are described in Section 1.3, along with the related Figs. 1-2 through 1-5. The measurement of the points on each segment must be accomplished without changing the reference of the coordinate system for each plate or in any other way disturbing the plate.

EQUIPMENT: Mann 422 Comparator with data logger.

OUTPUT:

1. Coordinate data on all points measured on 9.5- × 9.5-inch forward and aft panoramic segments.
2. All 9.5- × 9.5-inch glass diapositives ready for compilation test of 1:250,000.
3. Diapositives may be forwarded to UNAMCE operation 35.

OPERATION 15
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: CORRECT COORDINATE DATA FROM OPERATION 14 WITH COMPARATOR CALIBRATION CORRECTIONS

INPUT: Coordinate data of all points measured on 9.5- × 9.5-inch forward and aft panoramic segments

As a function of the comparator calibration log of the Mann 422 Comparator used in operation 14, the comparator calibration corrections referenced to the coordinate system of the comparator should be applied to the coordinates of the segment points measured.

EQUIPMENT: Computation equipment

OUTPUT: Corrected coordinate data of images measured in operation 14

OPERATION 16
TYPE: Coordinate Measurement

SECTION: Preparation and Measurement

TASK: MEASURE AND RECORD COORDINATES OF ALL CALIBRATION, CONTROL, AND MARKED RESEAU POINTS

INPUT: 9.5- × 18.5-inch glass diapositives of forward and aft panoramic frames. (These are the enlarged segments of the original 9.5-inch diapositives from operation 8.)

This operation is identical to operation 14 except that the plates are 9.5 × 18.5 inches, thus requiring a Mann 880 Comparator. All of the procedures are the same. (These plates are negatives.)

OUTPUT: Coordinate data on all points measured on the 9.5- × 18.5-inch glass diapositives of the forward and aft panoramic. Diapositives may be forwarded to UNAMCE operation 33.

OPERATION 17
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: CORRECT COORDINATE DATA FROM OPERATION 16 WITH COMPARATOR CALIBRATION CORRECTIONS

INPUT: Coordinate data of all points measured on 9.5 × 18.5-inch forward and aft panoramic segments

As a function of the comparator calibration log of the Mann 880 Comparator used in operation 16, the comparator calibration corrections referenced to the coordinate system of the comparator should be applied to the coordinates of the segment points measured.

EQUIPMENT: Computational equipment

OUTPUT: Corrected coordinate data of images measured in operation 16

OPERATION 18
TYPE: Analytical Comparison

SECTION: Preparation and Measurement

TASK: TRANSFORM AND COMPARE RAIL HOLE COORDINATES

INPUT: 1. Coordinate data on rail hole images of all forward and aft panoramic frames from operations 12 and 13.

2. Coordinate data of rail hole images from operations 14 and 15.

3. Coordinate data of rail hole images from operations 16 and 17.

Only rail hole coordinates will be compared. For computational convenience the coordinates of other data operations 14 and 16 may be carried through the transformations. This transformation and comparison is intended to analyze what geometric effects the photographic operations have had on the original material prior to operations 14 and 16. The transformation should contain scaling factors for the 2× enlarged plates.

The transformation will be of coordinate data output from operation 15 to the coordinate data output from operation 13 and coordinate data output from operation 17 to the coordinate data output from operation 13.

EQUIPMENT: Computational equipment

OUTPUT: Vector diagrams of the residual errors of the rail hole coordinates

OPERATION 19
TYPE: Analysis

SECTION: Preparation and Measurement

TASK: EVALUATE RESULTS OF OPERATION 18

INPUT: Vector diagrams of residual errors resulting from transformations of rail hole coordinates

It is the intention of operations 18 and 19 to determine whether or not our data reduction processing introduced significant geometric changes into the photographic images. Of particular interest in this determination will be the geometry of the images enlarged in operation 8. This is the only operation where an optical system was used to transmit the image from one record to another. Inherent in this evaluation will be geometric changes caused by photographic materials and emulsions.

EQUIPMENT: None

OUTPUT: Report on whether or not the enlarger used in operation 8 need be calibrated, or whether or not we are able to introduce segments into the enlarger locally consistent enough so that the geometrical distortions induced thereby are consistent in the output images. Operations 18 and 19 may be nonreoccuring operations for future application of this data reduction flow.

OPERATION 20
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: INTRODUCE PANORAMIC CALIBRATION CORRECTIONS FROM CALIBRATION LOG

INPUT: 1. Coordinate data from operation 15 (measurements made on 9- × 9-inch plates)

2. Coordinate data from operation 17 (measurements made on 9- × 18-inch plates)

Since the panoramic calibration corrections are an inherent part of the analytical operation which follows, a discussion of operation 20 would be included in Section II, "Control Intensification Computation."

OPERATION 21
TYPE: Photographic

SECTION: Preparation and Measurement

TASK: ENLARGE METRIC FRAMES (2) ON GLASS PLATES 9.5 × 9.5 INCHES

INPUT: Duplicate negatives of metric frames (2)

This operation involves the enlargement of the original input metric frames 4× onto glass. This is a standard procedure and requires no comment. Knowledge of the distortion characteristics of the enlarger would be desirable.

SUGGESTED MATERIALS: Kodak Super Aerographic Plates, medium

EQUIPMENT: B&L Precision Enlarger

OUTPUT: 9.5- × 9.5-inch glass diapositives of metric photography

OPERATION 22
TYPE: Point Transfer and Marking

SECTION: Preparation and Measurement

TASK: TRANSFER AND MARK ALL OF THE MARKED POINTS FROM THE FORWARD PANORAMIC TO ONE OF THE METRIC FRAMES

INPUT: 1. Marked forward panoramic diapositives from operation 11. This diapositive contains the forward panoramic image, rectified and reduced.

2. One of the metric frames enlarged in operation 21.

All of the marked control points in the forward panoramic frame are to be transferred to one of the metric frames. The forward panoramic diapositive has been brought to a scale operationally commensurate with the metric frame for point transfer in the VMI. The differential magnification between the panoramic diapositive and the metric diapositive will be 2:1. The metric diapositive may remain on one of the plate holders of the VMI while the panoramic diapositives are brought in sequentially. Only the marked model control points are transferred. None of the panoramic calibration data is to be transferred.

EQUIPMENT: VMI

OUTPUT: One of the metric plates containing transferred and marked control points from the forward panoramic diapositives. The panoramic diapositive both forward and aft, may now be forwarded to the M-4 Plotter operation 31.

OPERATION 23
TYPE: Point Transfer and Coordinate Measurement

SECTION: Preparation and Measurement

TASK: TRANSFER AND MEASURE ALL PANORAMIC CONTROL POINTS WITHIN METRIC MODEL

INPUT: 1. Metric frame containing panoramic control points transferred and marked in operation 22

2. Second metric frame

All panoramic control points which were transferred and marked on the metric plate must now be measured on that plate and transferred and measured onto the second metric image comprising the metric model. Since this is to be accomplished on a stereocomparator, it is not necessary to mark the control on the second frame, and measurements on both metric frames can be accomplished simultaneously as in a normal stereocomparator operation. It is also required to measure and record each of the metric reseau intersections circumscribing each of the transferred panoramic control points in order that all of these points may be established within the calibrated geometry of the metric camera.

EQUIPMENT: Nistri TA-3A or Wild STK-1

OUTPUT: Card output of coordinate data of all points measured in metric model. The card format should agree with the instructions in this document. Metric plates can be stored after completion of this operation.

OPERATION 24
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: CORRECT COORDINATE DATA FROM OPERATION 23 WITH COMPARATOR CALIBRATION CORRECTIONS

INPUT: Coordinate data of all points measured on 9.5- × 9.5-inch metric frames

As a function of the comparator calibration log of the stereocomparator used in operation 23, the comparator calibration corrections referenced to the coordinate system of the comparator should be applied to the coordinates of the points measured.

EQUIPMENT: Computational equipment

OUTPUT: Corrected coordinate data of images measured in operation 23

OPERATION 25
TYPE: Analytical Corrections

SECTION: Preparation and Measurement

TASK: INTRODUCE METRIC CALIBRATION CORRECTIONS FROM CALIBRATION LOG

INPUT: Coordinate data from operation 24 (measurements made on 9- × 9-inch metric plates)

Since the metric calibration corrections are an inherent part of the analytical operations which follow, a discussion of operation 25 would be included in Section II, "Control Intensification Computation."

3. TEST MATERIALS

The photographic operations required for the PG Data Reduction Test Plan are operations that are presently accomplished on a production basis. The stress in the functions herein described is on the controlled quality of the outputs of these operations.

3.1 CRITICAL OPERATIONS

Care must be taken to preserve a maximum of quality throughout the photographic operations. In the preliminary preparation steps, the operator must ensure the proper contact of materials in the contact printing operations. This is especially critical in the printing of the reseau to preserve the line quality so that the accuracy of subsequent mensuration operations will not be compromised.

In the enlarging operations for both the panoramic segments and for the enlarged metric input, the lenses should be of known quality and particularly in the case of the pan segment enlarger, the distortion characteristics of the instrument should be known.

In the preliminary point transfer operations incorporating marked PUG points, added care must be taken in the subsequent rectification and minification of the materials to preserve not only these points, but also to preserve the lines in the reseau so that the transfer to the metric image may be implemented. The major consideration in this operation will probably be the quality of the reduction. It may be necessary to make a number of test exposures varying both time and focus to achieve the best imagery. A through-focus test in this type of reduction is almost mandatory to achieve maximum resolution. The quality of the process lens used in this operation must also be considered.

3.2 QUALITY CONTROL

A quality control program, properly administered, is the basis for objective standardization. The application of control techniques to the production of photographic materials is an established tool in the conservation of manpower and material. Quality control procedures can be achieved with a minimum of impact on production operations and a maximum impact on the quality of the data reduction output.

During the initial setup and testing stages of an experimental data reduction scheme, it is important to obtain as much data as possible relative to the mechanical conditions of the process as well as the corresponding photographic effects. Also during this period it is necessary to conduct additional chemical analyses of the process chemistry over and above that already accomplished in the mix room. This is necessary to have a clear picture of the chemical reactions taking place as film is being processed so that replenishment rates and chemical life may be standardized.

Once the initial testing stage is complete and all of the parameters have been investigated, standardized, and controlled, the control procedures may be established. Exposure/development guides may be established, gamma determinations provided that are quick and reliable, chemical analysis procedures scheduled, and equipment control provided on a regular systematic basis. Record keeping should be designed such that a minimum amount of time is required with a maximum application of the information. Inspection data may be compiled and graphed for statistical studies to illustrate the quality of materials both received and generated. To achieve quality control in the data reduction, a number of relatively simple monitoring observations should be performed. These observations should be designed to produce a maximum of useful information with a minimum of time and skill.

The observations should be sufficient to ascertain that the system is under control. Simplified control charts should be developed so that rapid appraisal of the operations can be made. These charts will tell at a glance the level of control and what must be done if the quality level is not satisfactory.

In addition to the control charts, the operator should have definite instructions as to what course to take. As long as the control charts indicate that the equipment is operating within defined limits, but indicates a continuous high or low level, the operator would be required to report the situation to a supervisor. Control limits can be set so that continued operation for a short period of time will continue to produce films of the highest quality. These control limits are set after the period of initial testing so that the photographic coverage will be of consistently high quality even when the process is approaching the control limits.

Usually in the control of a photographic process, the control limits are set at 3σ levels, this being the usual procedure for color film processes. In the control of materials such as those produced by the PG System, it is suggested that 2σ levels be maintained to accord higher levels of quality by a more rigidly controlled process.

Since the equipment operates intermittently, there must be a regular check to ensure that it is ready for immediate operation when required. Transport systems, illumination measurements, and electrical monitoring should be checked during static periods. In addition it is wise to operate under "dummy" conditions to ensure readiness.

Periodic maintenance and calibration schedules should be established to ensure a continuous state of readiness for each equipment in the operation. There are generally three areas at which control information will be taken. The first consists of monitoring parameters such as temperature, voltage, etc., these usually being monitored automatically. The second area is one in which the operator measures easily monitored variables such as pH and specific gravity of instruments or light sources as well as chemical analysis of the processing solutions.

Sensitometric evaluation is programmed into the three areas mentioned above. For routine operations a minimum number of sensitometric and resolution targets is required, and the observations made from these targets can be kept to a minimum when the system is under control. If control levels begin to change, additional tests may be requested so that more extensive study can be undertaken.

Three methods of sensitometric testing should be accomplished. The first is a periodic system test. A master wedge incorporating targets of known quality should be processed through the system. The resultant sensitometric and resolution characteristics after each step can be evaluated. This approach ensures overall photographic and optical control.

The second level of control usually involves only the processing equipment and provides a continuous means of process control. The inclusion of control wedges and targets on the materials being processed should be considered on a regular scheduled basis and the information utilized to keep the control charts updated. This does not require extensive analysis of all levels of the step wedges, but only selected measurements at various levels corresponding to the major portions D-log E curve.

The third area of control is the analysis of resolution testing of printing equipment to ensure maintenance of quality levels.

3.2.1 Standards

Standards for photographic quality control are outlined in various American Standards Association publications, in Military Specifications, and in manufacturers' information guides and technical notes. Where standards are not available, they must be initiated according to the demands of specific situations. Standards may cover:

1. Environmental control (e.g., dust, humidity, and temperature)
2. Targets for high resolution tests
3. Sensitometry
4. Densitometry
5. Photometry
6. Photographic chemicals
7. Processing
8. Instruments for measuring environmental and chemical characteristics, dimensional change, etc.
9. Statistical analysis

3.2.2 Procedures

After quality control standards are adopted, they must be implemented by detailed procedures covering such photographic aspects as the following:

1. Handling of materials
2. Printing
3. Processing
4. Chemical mixing
5. Inspection
6. Interpretation and evaluation
7. Storage of materials
8. Recording of data
9. Maintenance
10. Cleanliness

3.2.3 Production Control

The key to uniform and high quality production is competent training and supervision to ensure that all standards are met. Procedures must be closely followed, production results must be correlated with standards, and all data must be properly logged and kept immediately available (see Fig. 3-1). Statistical analysis is an effective means of determining the efficiency of procedures in effect.

3.3 BASIC PROCESS CONTROL

To provide adequate control and to be assured that each and every photographic product used in the PG Data Reduction Test is of the highest quality, the following basic quality control procedures must be followed:

1. Every reproduction will have a minimum of one step tablet ([redacted] no. 2) imaged in the margin. Each reproduction will also incorporate resolution targets to provide means for evaluating each operation.

2. A control sheet will be kept for each frame of material used in the test and the pertinent data will be entered in a log book.

3. The step wedges incorporated in each reproduction will be read on a densitometer and the D-log E curves plotted. (In subsequent production operations, special techniques can be developed to reduce the amount of densitometry recording required.) As a rule of thumb, no reproduction should be accepted unless it retains a minimum of 11 steps of the 21 step wedge.

4. Where indicated in the Pilot Data Reduction Test Plan, the films recommended should be used. These have been chosen based on their exposure scale, latitude, and resolution to produce the best possible product. None of the materials referenced is unusual and should be readily available to AMS.

At the conclusion of this test, a report will be generated in which the tone reproduction of the materials will be evaluated and general conclusions as to what is required for production control can be prepared. At all stages of the test plan, it will be necessary to have sample reproductions available for evaluation and for visual aids at conferences.

Unless the quality of the photographic products is controlled the entire test will be compromised.

3.4 SUGGESTED AMS ACTION ITEMS

1. Run a controlled test with imagery, step wedges, and resolution targets through the entire reproduction cycle shown in the Data Reduction Test Flow Plan.
   - Keep Gammas low; consider Gamma products so that final plotting plates have an approximate Gamma of 1.2 and a corresponding density range of 1.2.
   - Keep exposures up off the toe of the D-log E curve.
   - Maintain records of all pertinent process and equipment data.
   - Use type SO-153 (estar base version of 8430) for all film operations and Kodak Super Aerographic Plates, medium contrast for all glass operations.
2. Prepare control methods for the Data Reduction Test based on the data obtained above.

ORIGINAL:

Frame Number ________ Mission Number ________ Generation ________

Physical Defects:

D_{max} ________ D_{min} ________

Subjective evaluation of data recording: Rail Holes

Scan Traces: Other:

Inspected by:

FIRST PRINTING:

Type of Film ________ Equipment ________ Exposure ________

D_{max} ________ D_{min} ________ Gamma ________

Remarks:

Inspected by:

SECOND PRINTING:

Type of Film ________ Equipment ________ Exposure ________

D_{max} ________ D_{min} ________ Gamma ________

Remarks:

Inspected by:

THIRD PRINTING:

Type of Film ________ Equipment ________ Exposure ________

D_{max} ________ D_{min} ________ Gamma ________

Remarks:

Inspected by:

ADDITIONAL SHEETS AS REQUIRED FOR EACH FRAME OF MATERIAL. IN SEGMENTING OPERATIONS INDICATE NUMBER OF SEGMENT.

Fig. 3-1 — PG data reduction test plan control sheet

[redacted]

[redacted]
ADDENDUM A
Copy No. 1

SUBTASK REPORT

PROBLEMS AND POSSIBILITIES OF HIGH ALTITUDE WORLDWIDE MAPPING

PANORAMIC GEOMETRY DATA REDUCTION TEST PLAN

SECTION 3: COMPILATION TESTS

1 March 1967

OPERATION 30
TYPE: Preparation

SECTION: Compilation Tests

TASK: PREPARE BASE MANUSCRIPT FOR M-4

INPUT: Ground point coordinates from operation 28 (Block Adjustment).

This operation is the routine function of plotting horizontal and vertical control data on the base manuscript (map grid sheet).

EQUIPMENT: Coordinate measuring and drafting equipment

OUTPUT: Base manuscript with grid and horizontal and vertical control plotted.

OPERATION 31
TYPE: Plotter Set-up

SECTION: Compilation Tests

TASK: SET-UP AND ORIENTATION OF M-4 PLOTTER

SUBTASK: Read and record model or manuscript coordinates of all plotted control points.

INPUT:

1. 9- x 18-inch forward glass plates from operation 22.
2. 9- x 18-inch aft glass plates from operation 11.
3. Base manuscript from operation 30.

Normal set-up of M-4 Projection Plotter using normal distribution and density of vertical and horizontal control. The subtask in this operation is to determine, by reading and recording, the model or manuscript coordinates of all control supplied in operation 28 and plotted in operation 30.

EQUIPMENT: M-4 Projection Plotter

OUTPUT: Coordinates of all control points

[redacted]

OPERATION 32
TYPE: Analysis

SECTION: Compilation Tests

TASK: COMPUTE ERRORS IN CONTROL POINTS OF M-4 TEST

INPUT: 1. Horizontal and vertical coordinates of all control points from model or manuscript.

2. Horizontal and vertical coordinates of all control points from operation 28.

(See operation 37)

[redacted]

OPERATION 33
TYPE: Plotter Set-up

SECTION: Compilation Tests

TASK: SET-UP AND ORIENTATION OF UNAMCE FOR 1:50,000 MAP TEST

SUBTASK: Read and record model or machine coordinates of all control supplied in operation 28.

INPUT:
1. 9- x 18-inch forward glass plates (negative) from operation 16.
2. 9- x 18-inch aft glass plates (negative) from operation 16.
3. Ground point coordinates from operation 28.

Normal numerical set-up and orientation of UNAMCE. The subtask in this operation is to determine, by reading and recording, the model or machine coordinates of all control supplied in operation 28.

EQUIPMENT: UNAMCE

OUTPUT: Coordinates of all control points

OPERATION 34
TYPE: Analysis

SECTION: Compilation Tests

TASK: COMPUTE ERRORS IN CONTROL POINTS OF 1:50,000 UNAMCE TEST

INPUT: 1. Horizontal and vertical coordinates of all control points from model or machine.

2. Horizontal and vertical coordinates of all control points from operation 28.

(See operation 37)

OPERATION 35
TYPE: Plotter Set-up

SECTION: Compilation Tests

TASK: SET-UP AND ORIENTATION OF UNAMCE FOR 1:250,000 MAP TEST

SUBTASK: Read and record model or machine coordinates of all control supplied in operation 28.

INPUT: 1. 9- x 9-inch forward glass plates from operation 14.

2. 9- x 9-inch aft glass plates from operation 14.

3. Ground control coordinates from operation 28.

Normal numerical set-up and orientation of UNAMCE. The subtask in this operation is to determine, by reading and recording, the model or machine coordinates of all control supplied in operation 28.

EQUIPMENT: UNAMCE

OUTPUT: Coordinates of all control points

OPERATION 36
TYPE: Analysis

SECTION: Compilation Tests

TASK: COMPUTE ERRORS IN CONTROL POINTS OF 1:250,000 UNAMCE TEST

INPUT: 1. Horizontal and vertical coordinates of all control points from model or machine.

2. Horizontal and vertical coordinates of all control points from operation 28.

(See operation 37)

OPERATION 37
TYPE: Analysis

SECTION: Compilation Tests

TASK: ANALYSIS AND REPORTING OF TEST RESULTS

INPUT:
1. Coordinate data from 1:250,000 M-4 Test.
2. Coordinate data from 1:50,000 UNAMCE Test.
3. Coordinate data from 1:250,000 UNAMCE Test.
4. Coordinate data from Block Adjustment (operation 28).

The compilation tests consist of reading the manuscript or machine coordinates of all points carried as control. These must be converted to northing, easting and elevation or latitude, longitude and elevation, or to whatever "survey" coordinates are used for comparison with the pre-established coordinates.

These measurement operations are straightforward for the UNAMCE since it possesses a comparator mode. For the M-4 compiled sheets, height measurements are made by reading the platen elevation. Planimetric measurements must be made on the Haag-Striet Coordinatograph. The recorded data must be punched into cards for input to the evaluation program.

The analysis of these data consists in converting the data from measurement coordinates to "survey" (operation 28) coordinates, these being the coordinates in which the control is known. If the control is in UTM coordinates for example, the analysis program must compute errors in northing, easting, and elevation for each control point. The mean value of each of these errors will be computed, as well as the standard error for each sample. The program will then determine if the sample meets the map accuracy standard.

The formulas for these computations are:

1. Error in northing for _i_th point

$$\varepsilon_N^i = N_c^i - N_s^i$$

where N_c^i = northing given by compilation

N_s^i = northing given by "survey"

Error in easting

$$\varepsilon_E = E_c^i - E_s^i$$

where E_c^i = easting given by compilation

E_s^i = easting given by "survey"

Error in elevation

$$\varepsilon_h = h_c^i - h_s^i$$

where h_c^i = elevation given by compilation

h_s^i = elevation given by "survey"

2. Mean values of errors for each sample

m = total number of points in sample

$$\bar{\varepsilon}_N = \left(\sum_{i=1}^{m} \varepsilon_N^i\right)/m$$

$$\bar{\varepsilon}_E = \left(\sum_{i=1}^{m} \varepsilon_E^i\right)/m$$

$$\bar{\varepsilon}_h = \left(\sum_{i=1}^{m} \varepsilon_h\right)/m$$

3. Standard errors for each sample

$$\sigma_N^2 = \left(\sum_{i=1}^{m} (\varepsilon_N^i - \bar{\varepsilon}_N)^2\right)/(m-1)$$

$$\sigma_E^2 = \left(\sum_{i=1}^{m} (\varepsilon_E^i - \bar{\varepsilon}_E)^2\right)/(m-1)$$

$$\sigma_h^2 = \left(\sum_{i=1}^{m} (\varepsilon_h^i - \bar{\varepsilon}_h)^2\right) / (m-1)$$

4. Radial standard error

$$\sigma_R = \sqrt{\sigma_N \sigma_E}$$

5. Circular Map Accuracy Standard

$$\sigma_{pm} = 2.1460\sigma_R$$

6. Circular Probable Error

$$CPE = 1.1774\sigma_R$$

7. Elevation Map Accuracy Standard

$$\sigma_{hm} = 1.6449\sigma_h$$