DEVELOPMENT AND PRODUCTION OF TWO-COLOR AERIAL PHOTOMOSAIC CONTRACT PLANS

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The increased complexity of highway design and construction has prompted the use of aerial photography and two-color printing to depict proposed designs more easily. A soft green ink is used to show the aerial photograph background and black ink shows the proposed designs. The technique is a departure from traditional drafting methods in that a base drawing is used for one color (green) and an overlay drawing for the other color (black). This method is compatible with the modern "scissors drafting" or "stick-up" technique now being used by many state highway departments. Results have shown greater clarity and increased flexibility in the use of aerial photography and better results in reproductions from black-and-white microfilm.

•THE Division of Highways, Wisconsin Department of Transportation, has developed a procedure to produce right-of-way and construction site plan sheets by using aerial photomosaics and two-color printing. This development dates back many years when it was felt that considerable effort was being spent to acquire conventional survey data and to draft these data merely for "picture" purposes. As a result, experimentation into the use of aerial photomosaics for plan sheets was begun.

We recognized early that we could not expect a true scale picture without going to a fully controlled ortho-photographic process; otherwise, the picture would be subject to all of the distortions inherent in normal aerial photography. If the distortions could be minimized in the area of the highway construction, however, the result would be satisfactory.

In addition to the cost savings generated by reduced field survey time and reduced drafting time, it was found that identification and the ability to "read" the plan were much better with photographs. This was especially true among the nonengineers such as property owners and local officials who were not accustomed to viewing typical engineering, line drawings.

However, after plans were produced for a couple of years by this method, it became increasingly apparent that the full utilization was being impaired by the black-and-white printing. When both the photograph background and the drafted engineering information were printed in black ink, there were areas where it was difficult to distinguish between the two, especially where there were shadows of buildings or other dark spots. This problem became even more apparent when microfilming of "as-built" construction plans began. Through the microfilm process of reducing to a small negative and then enlarging, much of the line work was lost in the background, which became much darker.

Thus a procedure was developed to print the right-of-way and construction plans in two colors: the background aerial photomosaic in a light green and the right-of-way and construction information in black. The "readability" of this plan is vastly improved, and microfilming is no longer a problem. It was also found that the two-color process has an excellent application to complex highway construction plans where aerial photography is not used. The existing conditions are shown with green, and the new con-

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struction is shown with black. Thus, much of the confusion caused by the multitude of all-black lines is avoided, and the plan is easier to use.

The preparation of the two-color plan using aerial photography requires a completely different concept of plan production than the traditional production methods. These procedures are described. The Appendix gives definitions of terms used in this paper.

AERIAL PHOTOGRAPHY

Prior to photography, field crews place white targets on selected stations of the surveyed reference line. These targets show up on the photographs and can be used to enlarge the photographs to a reasonably accurate scale. Targets are placed at a maximum spacing of $2\frac{1}{2}$ times the photograph scale so that at least 3 targets appear on each photograph. Targets can be made of white muslin, white paint, or other suitable material. If the placement of targets is not feasible, identifiable photograph images can be used for scale rectification, but it is not so desirable.

Most projects are photographed at a height of 2,400 ft by using a 6-in. focal length camera. The 1-in. to 400-ft scale photographs are then enlarged four times to the plan scale. On urban projects where plan scales are either 1 in. = 20 ft or 1 in. = 50 ft; photographs are taken at 1,200 ft (1 in. = 200 ft). Flight height restrictions over urban areas prohibit lower flying. Photographs are exposed with 60 percent overlap, and, when only the centers are used, distortion can be minimized.

The majority of the photographs were taken in the spring and fall when foliage is limited; however, where there are few trees, summer photography has been done with good results.

ENLARGEMENT-RECTIFICATION

A scaled pencil drawing of the survey alignment must be prepared prior to the enlarging process. The scale should be that of the desired plan sheet. On this drawing must be shown the placement of all targets (or photographic images). This drawing can be on vellum or any other suitable drafting material. Although vellum is subject to some shrinkage and expansion because of changing humidity, this does not seriously impair the scale of the end product.

The enlargement-rectification is done on a HE-12 enlarger. This camera is equipped with a four-way tilting easel such that some of the X- and Y-tilt of the photograph can be removed. The scaled drawing is placed on the easel, and the photograph is projected onto the drawing. Adjustments are made with the easel and the scale until the best fit is obtained on all targets.

When a 65-line, squared-dot, gray screen is used, a straight-up (emulsion-up), screened positive is produced. These screened positives are then laid over the scaled drawing to ensure accurate butt-splicing between photographs. After it is spliced, the photomosaic is trimmed to proper size and fitted into a standard base vehicle, and a reverse (emulsion-down) contact cronaflex positive (CCP) plan sheet is printed. This becomes the original plan base drawing for two-color printing.

PLAN PREPARATION

The preparation of a two-color plan requires production of a base drawing and an overlay drawing for each sheet of the plan (one drawing for each color). The base drawing will be reproduced in green, and the overlay drawing will be reproduced in black.

The standard base vehicle for the plan and profile sheet contains orientation marks and registration marks (Fig. 1). The orientation marks will be used for aligning the overlay with the base drawing during the drafting process. The orientation marks show the location of the borders and the title block in the upper right corner of the sheet. The registration marks are used in the offset printing process for registering the paper printing plates.

Any information to be printed in green must be added to the original plan base drawing. If this base drawing contains the aerial photograph, the information must be drafted directly onto the base drawing; the "stick-up" technique cannot be used. All information

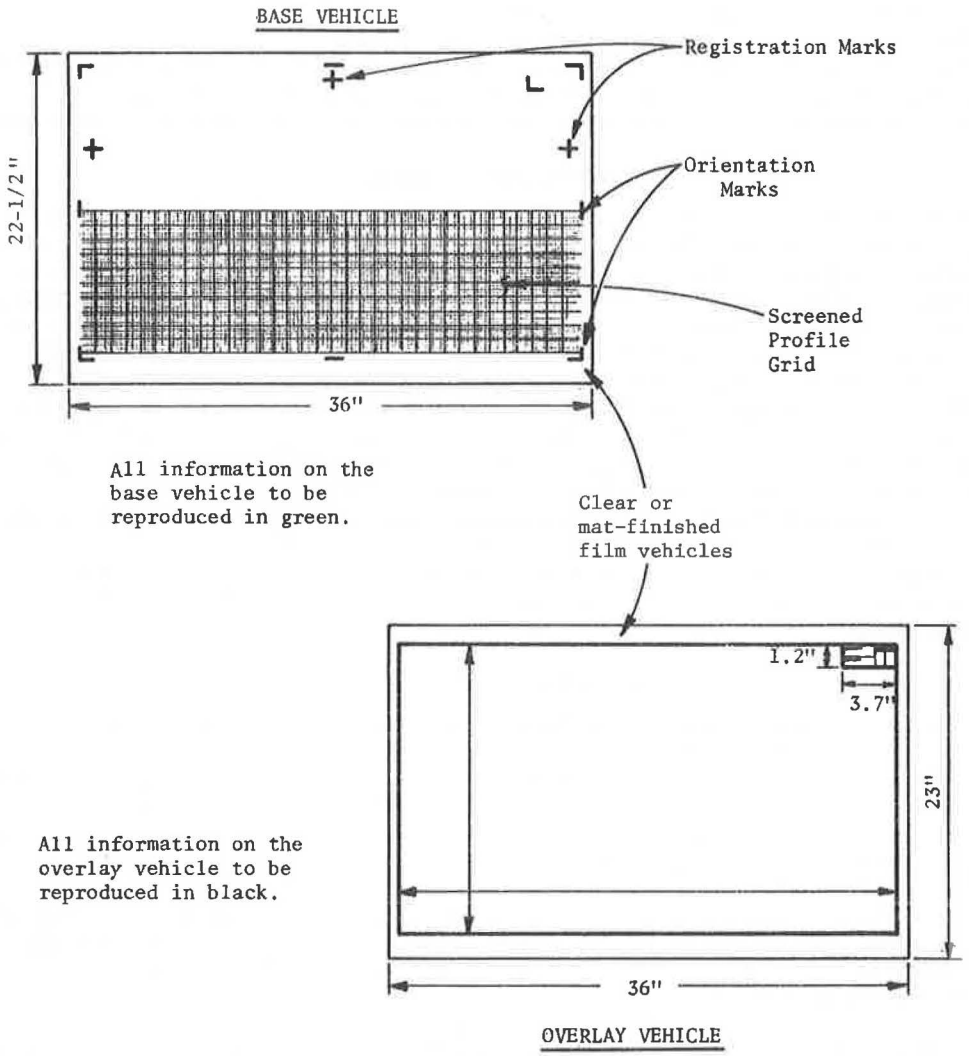

Figure 1. Standard Vehicles for Plan and profile sheets.

to be shown in black must be placed on the overlay. Two methods of preparing the overlay drawing are used. The first method is to use the stick-up technique and then to produce a mylar reproduction.

The steps used to produce a mylar reproduction are as follows (numbers are keyed to those shown in Fig. 2): The trimmed aerial photograph halftone (step 1) is positioned on the clear base vehicle (step 2). The photographic contract print process produces a first-generation reverse halftone contact cronaflex positive (CCP)(step 3). Pieces of drafting material are positioned on the original plan base drawing (step 4). The plan and profile designs are drawn (step 5). When complete, the design drawings are removed from the original plan base drawing (step 6). A clear overlay vehicle is positioned and secured over the original plan base vehicle (step 7). Plan and profile designs are repositioned and attached to the clear overlay vehicle (step 8). When complete, the original plan base vehicle and "stuck-up" design overlay vehicle are separated (step 9). The "stuck-up" design overlay vehicle is reproduced (step 10). This

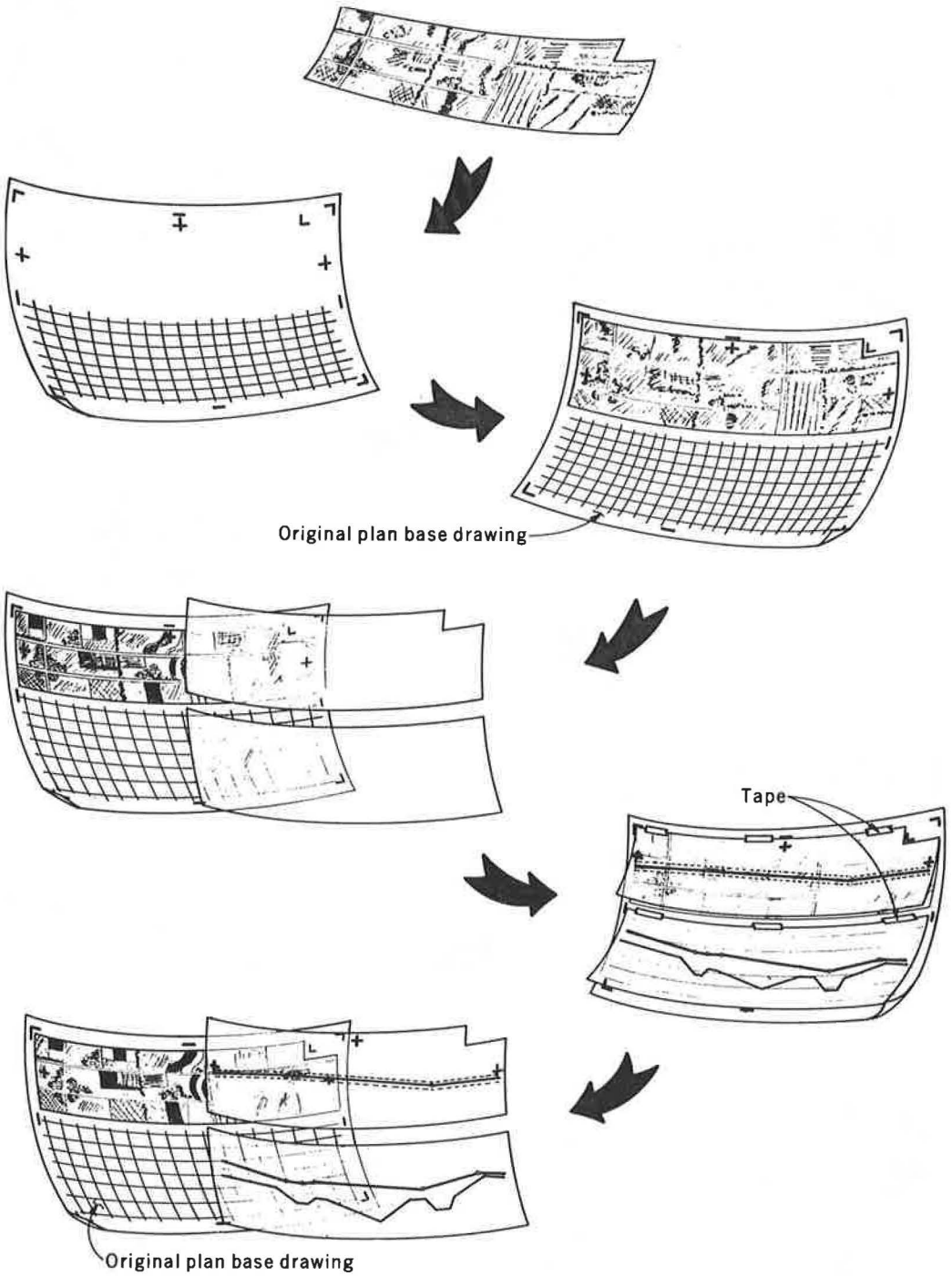

Figure 2. Steps in preparing mylar reproduction.

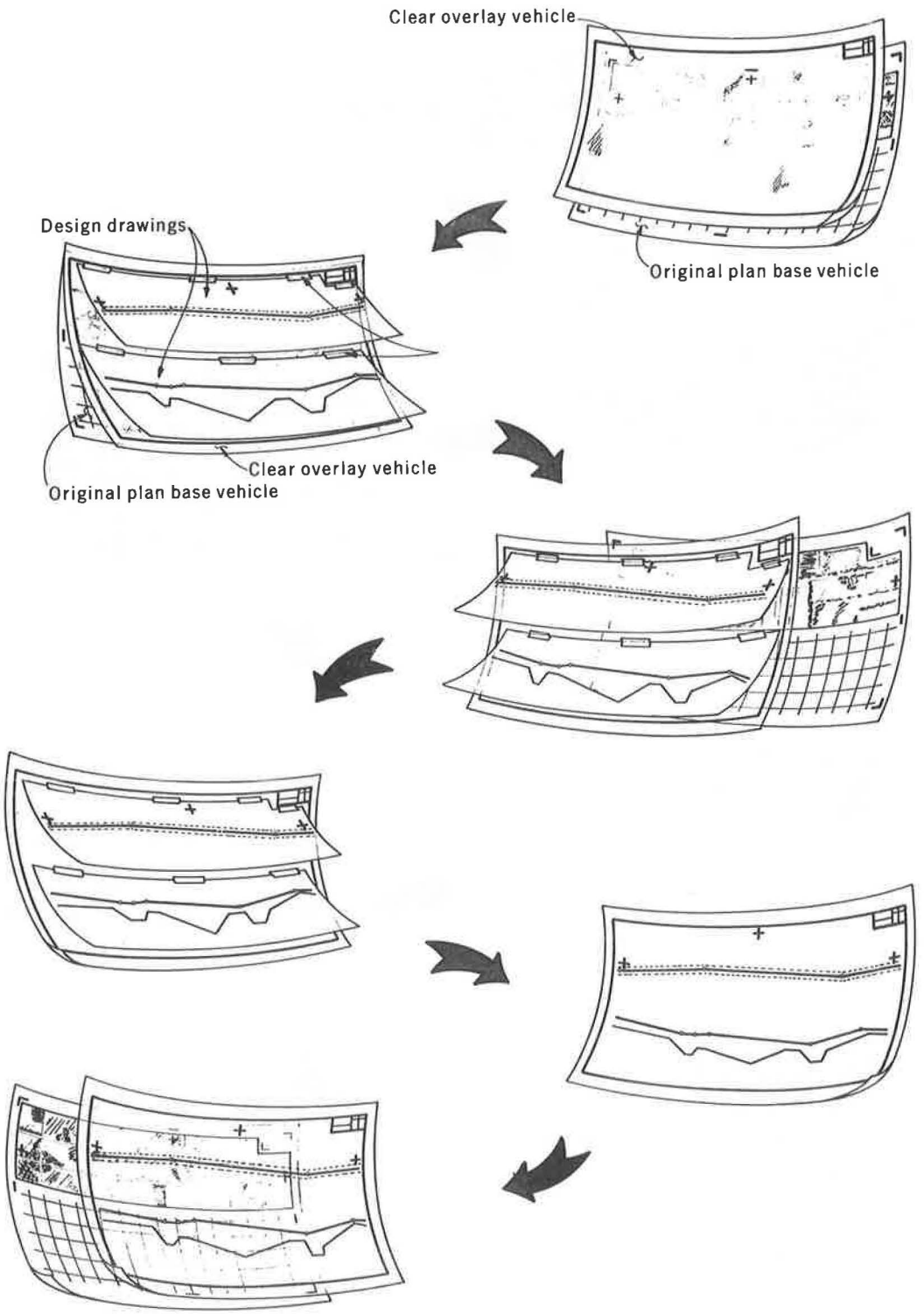

Figure 2. Continued.

yields a first-generation reverse mylar vehicle that is the original plan overlay drawing (step 11). This drawing, along with the original plan base drawing, is submitted for precontract administration (step 12).

After the drawings, original plan base drawings and original plan overlay drawings, are thoroughly checked for accuracy in precontract administration, the sheets are reproduced for distribution as contract plans. The sheets are separated, photographed, and reduced to half-size negatives from which paper plates for offset printing are made. On the first run through the offset press the green ink is printed; on the second run, the black ink is printed, producing the finished half-size plan sheet in black and green.

The second method is to draft directly onto the standard overlay. A mat-finished CCP of the standard overlay for the plan and profile sheets is placed over the base drawing, the border corners superimposed over the appropriate orientation marks. The two are taped together and the three registration marks are accurately traced onto the overlay. The remainder of the proposed plan and profile information is drafted directly onto the overlay.

At the time the plans are submitted for contract letting, there should be no visible discrepancy between the base drawing and the overlay vehicle. Normal expansion of the polyester material due to temperature and humidity will occur but will be much less than that of other drafting materials. Acceptable visual accuracy is achieved when registration marks are matched, when the proposed plan information falls into proper alignment with respect to the existing conditions on the base drawing, and when the profile line, corresponding elevations, and stationing fall on the proper profile grids.

PRINTING

When the plans have been approved for letting, they are sent to the reproduction unit. Here the base drawing and the overlay drawing are photographically reduced to half-size negatives. Paper offset printing plates are then made from the negatives. The plates for all of the base drawings are printed in green ink on a 15- by 18-in. offset press. Then the plates for the overlay drawings are used to overprint in black ink. This press will print only one color at a time, although presses are available that will print two colors in one operation.

The plates of the overlay drawing are adjusted to the print of the base drawing by the registration marks. The maximum allowable error for registering the plates is $\frac{1}{32}$ in. This degree of accuracy was found to be the most reasonable maximum error that could be maintained throughout the entire run with the methods and duplicating equipment used.

Accurate correlation between plan sheet information and registration marks is essential because the reproduction unit registers solely on the registration marks. The registration marks on the two drawings must match if overall accuracy is to be maintained.

APPENDIX

DEFINITIONS

Vehicle—a photographically processed polyester film sheet with a positive image used to hold drawings, details, notes, and so forth for reproduction. The vehicle may have a clear finish or a mat (frosted) finish.

Bass vehicle—a plan vehicle containing registration or orientation marks or both used to hold drawings, notes, mosaics, and the like that depict existing conditions for reproduction. A base vehicle is used with an overlay vehicle to produce colored plans.

Overlay vehicle—a plan vehicle containing the standard border and title block format for either a plan and profile sheet, a right-of-way sheet, or a construction detail sheet. An overlay vehicle is used with a base vehicle to produce a colored plan sheet.

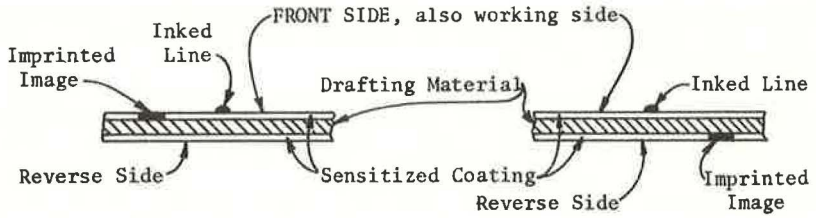

Figure 3. Straight-up versus reverse reproductions.

Original base/overlay drawing–any vehicle to which drawings or notes or both are attached. Also any original drawing with the base and overlay registration marks on which the plan information is presented in the form of an original ink drawing or mylar reproduction suitable for reproduction to half size for contract plan.

Registration marks–tick marks (+) printed on the base vehicles and used for registering the overlay vehicle to the base vehicle. These marks provide the guide for both the draftsman and the printer to register the two original drawings, one for each color.

Orientation marks–tick marks (⌐) printed on the base vehicles showing the corners of the standard border format. In the upper right corner of the base vehicle, additional tick marks are shown to outline the area occupied by the standard title blocks.

First-, second-, or third-generation reproduction–the number of times that an original drawing has been reproduced through successive intermediate reproductions from the original base/overlay drawings.

Straight-up and reverse–terms used to designate on which side of the reproduced drawing the image is printed. If the printed image is on the side of the sheet toward the reader, this is the straight-up side; if it is on the back or reverse side, this is the reverse side (Fig. 3).

Screening–the reproduction process used to allow the image, a continuous-tone photograph, or other drawing to be broken up into a dot-like or screened patterns so that it may be printed by the offset process.

Original plans–the linen sheets or mylar reproductions or both of the original base/overlay drawings that are submitted for processing into a contract plan.