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A Case for Orthophoto Mapping

Base maps are prepared for property maps or tax assessment maps.

Abstract: *This is a report on a property mapping project where the use of orthophoto imagery as a base proved to be highly advantageous. Detailed within this report are the methods and procedures utilized from project planning through client delivery. We present one case to support our contention that the use of the new tool of orthophotography employed in the production of property maps is a useful tool to the industry. Although savings are intangible in the main, the cost savings to the user for property mapping projects will prove to be significant. The savings curve will rise dramatically in the map production phase as the number of parcels in a project increase, because more inexperienced personnel would most likely be employed. In addition, the increased value of the ortho product versus conventional line maps to the layman user is a virtue not to be overlooked.*

Ocean County, New Jersey is the second-fastest-growing county in the United States. It is within easy reach of the New York and Philadelphia Metropolitan areas. The result has been a tremendous real estate boom within the past 15 years.

Within Ocean County, two townships which had previously been rural in nature were suddenly caught up in the boom that had already gripped most of the county. Real estate values doubled, trebled, and increased tenfold. With advent of these changes, officials of the two townships realized that they lacked the essential tools for maintaining an accurate inventory of the parcels of land within their towns. They did not have accurate, up-to-date property maps or tax assessment maps.

So it was that the officials of Manchester Township and Plumsted Township negotiated contracts with the firm of Ernst, Ernst and Lissenden of Toms River, New Jersey, Consulting Engineers, who subsequently engaged Aero Service Corporation, a Division of Litton Industries, to prepare the base mapping portion of the project.

Whereas the two townships actually have a common boundary, they are very different from each other in topography and land use. Manchester is covered almost entirely by scrub pine and oak trees with few large land holdings. Plumsted, on the other hand, contains numerous large farms, among them the home of Stanley Dancer (Figure 1), famous breeder and trainer of harness-racing horses, and portions of the township are heavily-wooded with large hardwood trees.

Years ago these hardwood stands were subdivided and sold as small woodlots for the cutting of stovewood, and title of many of them had become lost for assessment purposes. A significant part of the mapping effort would be to determine the location and ownership of these woodlots.

As a first step it was necessary to select the mapping method that would be utilized for the project map base. The choice lay between:

- The land surveyor's method of establishing a traverse network along existing roads;
- Rectified enlargements of aerial photographs used in conjunction with existing property surveys;
- A photogrammetric line-drawn base;
- The relatively new process of orthophotography.

After considering the cost-benefit ratio of each type of base map, it was decided that new aerial photographs should be obtained

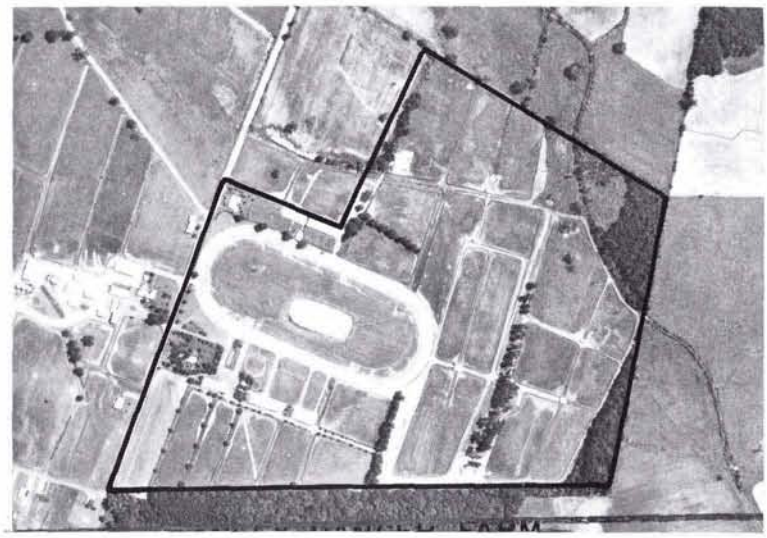

FIG. 1. The Stanley Dancer Farm.

and an orthophoto base be prepared for each township. In making this decision, much weight was placed on the fact that cut lines through the woods, resulting from new and old surveys, as well as the many other land net and physical features that assist in identifying property lines, would be clearly identifiable in the orthophoto base (Figure 2). In addition all such linear features would be in their specific and interrelated location because the accuracy of the orthophoto base is in its horizontal dimensions. Experience has proven that providing the property compiler with a base map with accurate dimensional scale will produce significant cost savings. Furthermore, farm boundaries and the many other land features that assist in identifying property boundary lines would be most evident in the orthophoto base.

TO ACHIEVE the desired base map accuracy, photo-identified ground control was necessary. An investigation of existing monumented control revealed that in both Town-

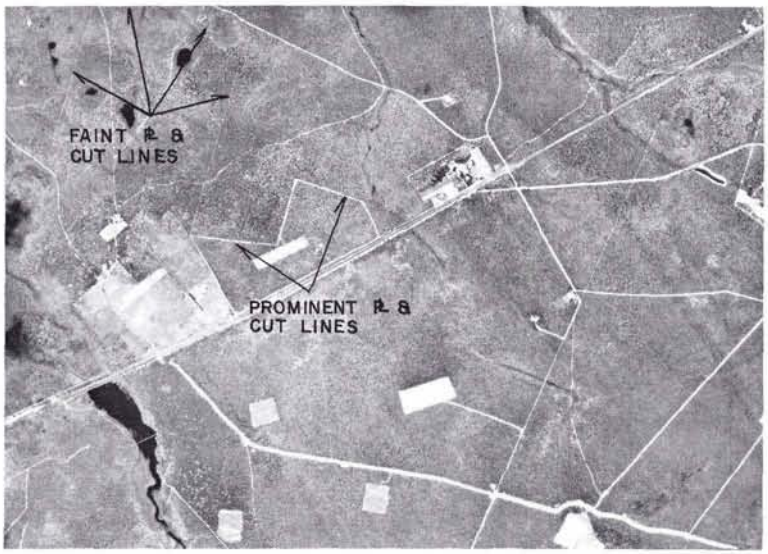

FIG. 2. An example of trace lines in wooded areas.

ships, there were sufficient horizontal and vertical New Jersey Geodetic Survey Control points to make it unnecessary to establish additional ground control. Used in conjunction with analytical bridging techniques, the existing control was extended by means of a block adjustment to cover the entire project area. The positions of the New Jersey Geodetic Survey control monuments were pinpricked on a set of prints of the newly-obtained aerial photographs, the spatial coordinates noted, and the data made available for the performance of analytical triangulation.

It should be noted that more rigid control must be maintained through the planning, processing, acceptance and production of aerial photographs intended for orthophoto use than is required for normal stereophotogrammetric compilation purposes. Due consideration must be given to the unique mechanical and optical limitation of the ortho restitution equipment to be employed, similar to planning for stereoplotting equipment. In addition to this, the side overlap of photo strips can become critical due to maximum model area coverage within a single orthonegative and the compatability of the final negative size with laboratory projection equipment.

As we are dealing at our final product scale with photographic images which are direct descendants from the original aerial film, the film defects, which would normally be considered very minor (such as scratches, blemishes or water spots) become major problems on a final orthophoto product. Image resolution must be optimum; film processing to required densities is critical; strip-to-strip film or subject-contrast variations must be controlled. The diapositives produced from the aerial film, whether film or glass base, require the same quality-control as that exercised on the original film.

The delivery requirements for this project dictated the acquisition of aerial photographs at two scales suitable for final orthophoto scales of 200, 400 and 800 feet to the inch.

Analytical aerial triangulation was performed on the higher-altitude photography, with a transfer of selected image points from the lower altitude sufficient to provide individual model control for the limited amount of 200-scale production. The analytical triangulation process utilized point-marking devices augmented with equipment to facilitate the accurate transfer of drilled positions from one photo set to the other.

Unique to triangulation for ortho production is the positive requirement that all control points, including supplemental model control points, must be selected at ground level. If this is not observed, drilled positions on images with relief will result in the image not being coincident with the coordinated position on the final negative because the ortho exposure is made from a single non-restituted image frame.

Although positional accuracy of any given feature was not critical for the purpose of the final product, sufficient passes through an IBM 1800 process system were made to achieve an RMSE solution in x and y within a maximum value of 1.4 feet to 2.7 feet at the respective photo scales.

Using the SFOM D693 Orthorestitutor and subsequent photo-mechanical enlargement to desired scale, orthonegatives were produced within the accuracy limits that are accepted in the industry for standard line-drawn engineering maps. For those areas of the project containing primarily State and Federal land, the final product was at 800 feet per inch, printed on an opaque polyester base photographic material. Rural and woodland areas were delivered at 400 ft. per in. and urbanized areas were at 200 ft. per in. A rectangular grid based on the State Plane Coordinate System was incorporated into each final sheet.

The compilation of property lines was accomplished on overlay manuscripts to the orthophoto maps. Each overlay contained a five-inch grid to coincide with the grid on the orthophoto. All existing property survey maps and subdivision maps were gathered together, located, and plotted on the compilation manuscripts. It was desirable to plot first all lines on which surveys had been made, because these distances and bearings would remain unchanged.

In each Township, the Assessor's records included a good file of deed abstracts supplied by the County Clerk's Office. These abstracts were the primary source for metes-and-bounds descriptions of the many parcels for which no surveys existed. Where no abstract was available, it was necessary to resort to the records in the County Clerk's Office. Plots of the descriptions were made on translucent material to allow assembly directly over the base maps.

During the process of assembling the deed plots and plotting the positions of the prop-

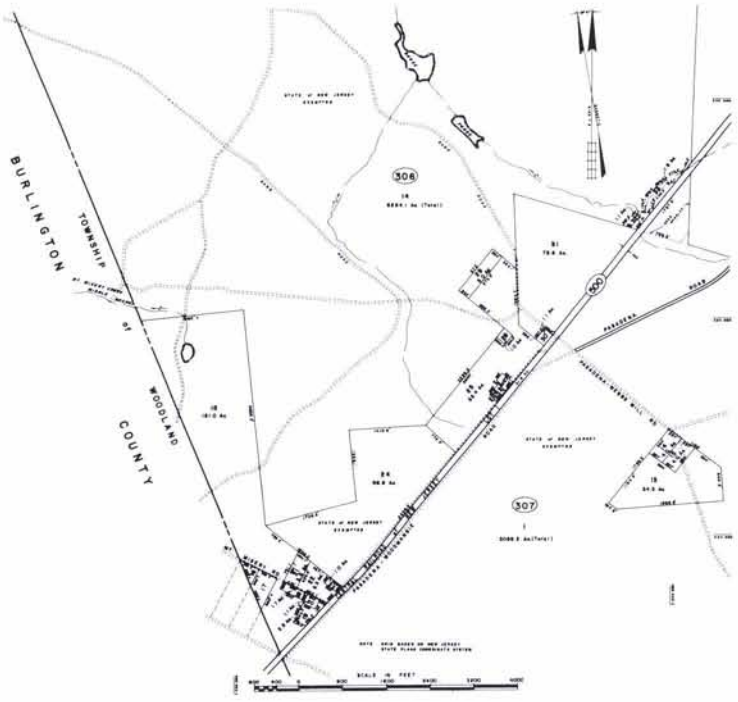

FIG. 3. A final property map.

erty lines, the value of the orthophoto base became increasingly evident. Only the more obvious property lines are normally portrayed on *line-drawn* maps because they would not include faint and intermittent linear features which are not clearly interpretable as possible property lines. To compile the maximum number of these features would prove uneconomical because many are not, in fact, property lines. In addition, small parcels lying within large tracts are not usually shown, causing the compiler to work between photographic prints and the base map to position the smaller tracts accurately. This is a major source of error with less-experienced compilers and one of the most difficult problems to overcome in training new compilers. The orthophoto not only shows *all* lines, but all other physical features including buildings, as well, which is helpful in locating a parcel's boundary lines; particularly of small tracts. The largest single benefit from the use of orthophoto for property compilation is the fact that compilers with lesser experience can be gainfully-employed on problem areas of compilation.

ALL drainage, railroad and highway features were transferred from the ortho base to the compilation manuscripts at the time of property line determination.

Final inked drawings were made by tracing all information directly from the compilation manuscripts with dimensions and other lettering added by use of mechanical lettering guides (Figure 3).

The scaling accuracy of the orthophoto was most evident where large tracts having boundary lines a mile or more in length were compiled. Upon being scaled on the base maps, these mile-long lines plotted with an immeasurable difference. Rural areas were mapped at 400 ft. per in. and urban or subdivided areas at 200 ft. per in. so that accurate plotting should fall within 10 feet at the scale of 400 ft. per in. and within 5 feet at the scale of 200 ft. per in. Line after line consistently fell within these tolerances. The resultant tax maps are commendably accurate as to the location, size and shape of each parcel. Moreover, property surveys made subsequent to the compilation of the tax maps have also fallen into position repeatedly, with no adjustment to the lines being required.

SEVERAL recent land surveys in the project area have been referenced to the New Jersey Plane Coordinate System with coordinates

given for the property corners. Where these coordinate positions also were plotted on the tax maps, deviations were within the accuracy parameters for the respective scales.

Property maps prepared by the methods described here are of incalculable value to the user. However, property maps are only as good as the date of their last revision. With the methods used on this project, the final property lines are not applied directly to the ortho base, but to the inked line maps that then can be up-dated in a conventional manner. In this way the major objection to orthophotos, that is, the expense of revision, is lessened, as the orthophoto base itself will not have to be up-dated.

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2. Ordinarily *two* copies of the manuscript and two sets of illustrations should be submitted where the second set of illustrations need not be prime quality; EXCEPT that *five* copies of papers on Remote Sensing and Photointerpretation are needed, all with prime quality illustrations to facilitate the review process.
3. Each article should include an abstract, which is a *digest* of the article. An abstract should be 100 to 150 words in length.
4. Tables should be designed to fit into a width no more than five inches.
5. Illustrations should not be more than twice the final print size: *glossy* prints of photos should be submitted. Lettering should be neat, and designed for the reduction anticipated. Please include a separate list of captions.
6. Formulas should be expressed as simply as possible, keeping in mind the difficulties and limitations encountered in setting type.

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