**CHAPTER 7**

# Map Compilation

## 7.1 HISTORY

Producing accurate commercial maps from aerial photography began in the 1930s. The technology of stereomapping over the last 70 years has brought vast technological improvements.

### 7.1.1 Stereoplotters

Stereoplotters are machines that incorporate complex optical train viewing systems with computer-driven precision instrumentation. These components are employed in extracting, analyzing, and recording spatial information from aerial photographs. A spatial model is a stereopair of photographs referenced to its true geographic position, and stereoplotters utilize models in the collection of spatial data. A pair of near-vertical aerial photographs exposed from two different locations, with sufficient overlap of the area of interest, allows the operator to view a two-dimensional image in three dimensions. Stereoplotters use film positives of the exposures of interest as the spatial stereopair media. These film positives are commonly referred to as diapositives in the photogrammetic mapping industry and are produced as a second-generation positive transparency on machines, such as that seen in Figure 7.1, which electronically dodges the image to eliminate undesirable light and dark areas.

The operator inserts consecutive overlapping diapositives into receptacles residing within the stereoplotter. Even though the compiler is actually viewing two separate images, proper relative alignment of the photos allows the operator's mind to fuse images into a reduced three-dimensional diorama of the overlapping area as it appears to float in spatial limbo.

Figure 7.2 is a view of an analytical stereoplotter in operation, similar to a selection of instruments marketed by various manufacturers that are the mainstay of contemporary stereomapping. Items that are visible in Figure 7.2 are:

**Figure 7.1** An electronic dodging machine used to produce film plates employed in stereo-mapping. (Photo courtesy of authors at Walker and Associates, Fenton, MO.)


**Figure 7.2** An analytical stereoplotter in operation. (Photo courtesy of authors at Walker and Associates, Fenton, MO.)

- The monitor to the left of the technician controls the computer which drives the system.
- The monitor to the right of the technician displays the map compilation features.
- The binoculars allow the technician to view the three-dimensional image.
- The tracing cursor allows the technician to guide the internal floating reference mark to compile the mapping data.

#### 7.1.1.1 Georeferencing

To compile spatial data in their correct location, both horizontally and vertically, the stereomodel must be referenced to a prescribed vertical and horizontal datum. In the surveying and mapping industry this is referred to as georeferencing the stereomodel. A minimal number of ground points that are identifiable in the stereopair must be known for proper georeferencing. The operator employs prescribed procedures to measure and adjust the location of stereopairs in space to the locations of the known ground features. These procedures are repeated until an acceptable spatial location of the stereopair is obtained and satisfactorily georeferenced.

After the photos are properly oriented, the internal reference mark is maneuvered horizontally and vertically to read the true XYZ (east/north/elevation) geographic position of any point on the stereomodel.

#### 7.1.1.2 Data Compilation

Once a stereopair is properly georeferenced in a stereoplotter, the data can be viewed, interpreted, and compiled. Data compilation is the collection of information pertaining to and describing features within a stereomodel, accomplished by interpretation of the object type whether it is topography, structures, utilities, natural features, or vegetation. Data compilation may also include the shape and position (horizontal and vertical) of a selected feature relative to other features in the stereopair. Topography is compiled as points of known elevation, which can be mathematically interpreted into contours (lines of equal elevation) by software applications.

### 7.1.2 Evolution of Stereoplotters

The implementation of stereoplotters has passed through three distinct mechanical generations and is now in a digital environment. Mechanical stereoplotters can be generally defined by the fact that they require film products of the area of interest and an optical train (a series of lens and prisms) device to view in three dimensions. Digital stereoplotting systems are commonly referred to as softcopy mapping systems, which incorporate high-density scanned images, coupled with high-resolution computer screens, high-speed processors, unique suites of map feature compilation software, and digital data storage devices.

Readers who wish to learn more about the obsolete mechanical forerunners of contemporary mapping instruments can refer to Chapter 7 in *Aerial Mapping: Methods and Applications* (Lewis Publishers, Boca Raton, FL, 1995).

#### 7.1.2.1 Digital Stereoplotters

The 1980s ushered in the third generation of stereoplotter, which is equipped with internal control computer systems and data collectors. These systems, termed analytical, create a mathematical image solution, allowing the computer to perform model orientation. High-speed computers and complex software are employed as

**Figure 7.3** A softcopy system. (Courtesy of Surdex Corporation, Chesterfield, MO.)

drivers that move the data collection point to the desired precise location for feature collection.

The optical/mechanical construction of a digital instrument allows for the collection of feature coordinates simultaneously from two successive overlapping photographs. This improved feature position accuracy is accomplished by computer software that interprets and converts the differential parallax of feature coordinate sets from the overlapping photographs into precise geographic locations.

When the map compilation is in progress, some analytical systems require the operator to work from a three-dimensional image while looking directly into the viewing binoculars, and the compiled data appear on a graphic screen. A combination software/hardware unit interjects the generated digital information into the optical path of the train of optics and reproduces it directly on top of the spatial photo image.

#### *7.1.2.2 Softcopy Systems**

In the 1990s computer processing speeds increased dramatically, almost simultaneously with continuous increases in data storage. The technological advancements in computer processing and data storage also drove the demand for very high-resolution image scanners. These technology changes and demands drove the mapping industry to a total softcopy solution for mapping.

* The internet keywords "softcopy mapping" leads to several pertinent web sites pertaining to softcopy mapping, including references to equipment, images, contour maps, orthophotos, digital elevation models, GIS, and other applicable items of interest.

The operation of a softcopy system such as that seen in Figure 7.3 requires a different approach from that employed in the operation of stereoplotters. Each of the photos used to form the stereomodel is scanned, and the data are input into a database.

Similar to the first analog systems of the 1960s and 1970s, each photo in a stereopair is viewed independently by the operator with the use of polarized glasses, enabling the technician to view each image, correct for parallax, and view the overlapping area of the stereopair in three dimensions.

The web site http://www.rwell.com/dms.htm describes a desktop mapping system that operates on the softcopy principle.

Softcopy mapping systems generally require several components, including a large format graphic screen, a high-speed central processing unit, large data storage units, and a high-resolution metric scanner, coupled with several software packages. Software packages would be required to perform georeferencing of stereopairs, digitizing, annotation, image manipulation, and database management. Additional software packages may be required to perform GIS functions.

Recent developments in digital camera systems allow mapping system developers to eliminate the film and diapositives. Overlapping digital images of a mapping area are collected and stored as digital data with the use of high-resolution metric digital cameras. This digital image data is then entered directly into the softcopy mapping system. As the technology of digital camera imagery approaches the image quality of silver-grained emulsion film, total digital photogrammetry is becoming a reality. When properly employed, digital camera imagery is capable of producing the same mapping products and required accuracies as those produced with traditional film products. The time needed to complete mapping projects could also be reduced by the elimination of film processing, diapositive production, and printing.

### 7.1.3 Future Developments

Photogrammetric mapping system technology undergoes constant evolution due to the constant changes in computer technology. The need and demand for geographic information also drive these developments. There is an ever-increasing need to pinpoint happenings in the world. Digital camera technology enhancements include multispectral and hyperspectral camera systems in light fixed- and rotary-winged aircraft. Laser mapping technology — light detection and ranging (LIDAR) — has developed to a point where it is being deployed in fixed and rotary aircraft to collect accurate point locations (X, Y, and elevation), which can then be processed to produce topographic information. Satellite mapping system development is not only performed by major governments; private industry around the world will be developing orbiting mapping systems with data available to the private sector at competitive rates. Mapping systems will be developed that eliminate the need to manually collect many common features such as buildings, roads, and vegetation. Mapping production technology will increase the compilation speed and accuracy to a point where it is collected in near real time. These changes are ongoing, and many of them have been under development for several years.

## 7.2 DATA FORMAT

Information is created and stored in several different modes.

### 7.2.1 Raster Format

Raster data are scanned from a photograph or graphic image or are collected by a multispectral scanner, thermal scanner, or radar. The image is composed of rows and columns of numerous picture elements, individually known as pixels. Each pixel has a defined size and specific incident flux value indicating a specific type of information. Radiation intensity is graded from 0 (no reflectance), which exhibits a dark image, to 255 (full reflectance), which exhibits a bright image. Figure 7.4 illustrates a set of raster data aligned in columns and rows of picture elements with a single pixel isolated as the hatched frame.

Many mapping projects require the mapping scientist to scan imagery in order to incorporate it into a mapping system for feature compilation and/or analysis, which may require a high-resolution metric scanner. Figure 7.5 illustrates a scanner in operation. A photo scanner is basically a densitometer working as an analog-to-digital converter. It records the radiometric density value of a discrete pixel on the photographic image in the form of a binary integer.

High-resolution photo scanners are generally constructed as flatbed or rotary and are capable of scanning translucent as well as opaque media. Scanners used for map compilation today may also be capable of scanning color imagery. Some color scanners scan red, green, and blue in separate passes, while others are capable of scanning all three primary colors in one pass. Scanning devices are designed to hold the film in place as a light source passes over it, and a photomultiplier records the image density of each pixel. Some of the major differences in scanners include the flexibility of scan resolutions, the scanners maximum and minimum scan resolution, one-pass or three-pass color scanning, and the ability to scan from a roll of film. Most of these differences, with the exception of scan resolution capability, only affect the time to produce a scan and not the quality.

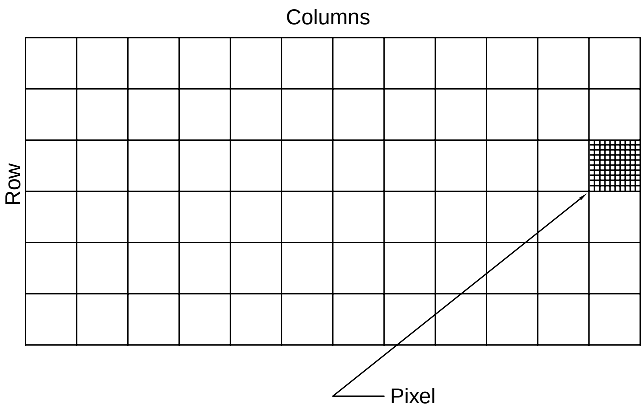



**Figure 7.4** Raster data format.

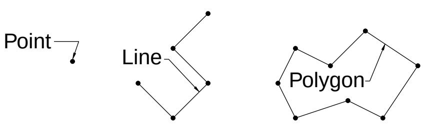
**Figure 7.5** A scanner in operation. (Photo courtesy of authors at Walker and Associates, Fenton, MO.)

Pixels extracted from the raster scan of a photograph could be as small as 1/1000 in. or even as minute as 1/5000 in. for use in some softcopy environments. The ground dimension of pixels collected by resource satellites is in the range of 10 or 20 m from the French Systeme Pour L'Observation de la Terre (SPOT) satellites and 30 m or 120 m from the American LANDSAT resource satellite. The resolution of pixels captured with meteorological satellite technology is even larger, exceeding 1 km.

### 7.2.2 Vector Format

Vector data are generated in planar or spatial Cartesian coordinate data strings, as illustrated in Figure 7.6, forming points, lines, and polygons:

- A point is located by a single XY or XYZ coordinate set.
- Lines are composed of a series of points connected by vectors.
- A polygon is a succession of lines enclosing an area.




| Feature | Cartesian Coordinates |
|---|---|
| Point | X,Y |
| Line | X,Y (1).... X,Y (n) |
| Polygon | X,Y (1).... X,Y (n),X,Y (1) |

**Figure 7.6** Vector data format.

**Figure 7.7** A data editing system. (Photo courtesy of authors at Walker and Associates, Fenton, MO.)

### 7.2.3 Attributes

Collateral textual information resides in the database to describe, explain, supplement, or identify the raster and vector data. Tabular attribute information can be retained in accessible matrices.

## 7.3 DIGITAL OUTPUT

Once the data are collected, it is input into a data editing system such as the one shown in Figure 7.7 to assure its reliability.

Output from map compilation and geographic analysis can include the following:

- Natural and man-made cultural features
- Digital terrain model data, breaklines, and spot elevations for the development of contours, wireframes, perspective views, and orthophotos
- Terrain profile data to be used in stockpile or excavation volumes and earth movement calculations
- Digital orthorectified photographs

Output media for map compilation data may include magnetic tapes, hard drives, diskettes, and CDs. Hardcopy data sets may include line maps or image renditions, or a composite of both can be created from the raster or vector files on a data plotter. Hardcopy media may include bond paper, velum, and/or photographic paper plots.