National Mapping Program
Technical Instructions

Standards for Digital Orthophotos

U. S. Department of the Interior
U.S. Geological Survey
National Mapping Division

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Part 1
General

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Standards for Digital Orthophotos
Part 1: General

1. GENERAL

1.1 DEFINITIONS

The term "digital orthophoto" is used throughout this document to refer to both the "digital orthophoto quadrangle" (DOQ) and "digital orthophoto quarter-quadrangle" (DOQQ) products. A digital orthophoto is a digital image which has the properties of an orthographic projection. It is derived from a digitized perspective aerial photograph by differential rectification so that image displacements caused by camera tilt and relief of terrain are removed.

Orthophoto chips - A digital orthophoto may be made up of several images which are mosaicked together to form the final image. Each separate piece of the mosaic which contributes to the final image is called a "chip".

1.2 OBJECTIVES

The U.S. Geological Survey (USGS) is designated as a lead Federal agency for the collection and distribution of digital cartographic data. The standards specified in this document pertain to the collection, processing, archive, and quality control of digital orthophoto data. Data produced to this standard will be archived in the National Digital Cartographic Data Base (NDCDB).

The U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS); U.S. Department of Agriculture, Soil Conservation Service (SCS) and the U.S. Geological Survey, National Mapping Division (NMD) cooperate in a digital orthophoto program that meets each agency's requirements, as well as serves the broader user community for digital imagery data. The ASCS and SCS use digital orthophotos as a common base map to facilitate the collecting, organizing and sharing of natural resource data at county field offices. The NMD plans to extract digital base category data directly from digital orthophotos. This standard supports these orthophoto requirements. Given

that the requirements and technologies involved in producing digital orthophotos will remain dynamic for some time, this standard outlines many of the key dependencies involved in producing digital orthophotos and, in some cases, alternative methods of production.

This document also provides USGS components with guidelines for performing quality control and acceptance of digital orthophoto data into the NDCDB. Data generated by ASCS, SCS, and NMD, other Federal agencies, or acquired through procurement from the private sector, shall also conform to this standard, in order to be accepted for entry in the NDCDB.

1.3 PRODUCT DESCRIPTION

Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. They serve a variety of purposes, from interim maps to field references for earth science investigations and analysis. The digital orthophoto is useful as a layer of a geographic information system and as a tool for revision of digital line graphs and topographic maps. A digital orthophoto, as described in these standards, can be produced from any scale of photography. However, the program is oriented primarily toward the production of 1-meter digital orthophoto quarter-quadrangles from 1:40,000-scale National Aerial Photography Program (NAPP) or NAPP-like photography. Production of 2-meter digital orthophoto quadrangles will be primarily from National High Altitude Photography (NHAP) or NHAP-like photography (1:80,000 scale), however may be supported by the mosiacking of digital orthophoto quarter-quadrangles. At the present time, hard-copy outputs from the digital orthophotos include 1:12,000-scale orthophoto quarter-quadrangles and 1:24,000-scale orthophoto quadrangles. Image processing algorithms can be applied to the image data to support image classification, three dimensional modeling, and many other spatial applications.

The digital orthophoto is created by scanning an aerial photograph diapositive transparency with a precision image scanner. The scanned data file is then digitally rectified to an orthographic projection by processing each image pixel through photogrammetric space resection equations. This process requires, as input, ground control points acquired from ground surveys or developed in aerotriangulation, camera orientation parameters, and a digital elevation model (DEM). The rectified digital image is then archived on suitable digital storage media

with informational header records inserted as the first four records of the digital image file. The image may also be written to film by a digital film writer.

1.4 SOURCES

The production procedures and instrumentation used for the collection of digital orthophotos vary depending on what systems are available. At the present time, NAPP or NAPP-like photographs are the primary source used for the production of digital orthophotos by the USGS. NAPP photographs are quarter-quadrangle centered (3.75 minutes of longitude and latitude in geographic extent) and are exposed at a flying height of 20,000 feet above mean terrain with a 152.4 millimeter focal-length camera (photography scale = 1:40,000). Quadrangle (7.5-minute) digital orthophotos are produced either by mosaicking 3.75-minute digital orthophotos or digital orthophoto chips or from NHAP. Color-infrared photographs may be used as a source for digital orthophotos; however, the digital image file is a black-and-white (B&W) digital orthophoto. Other aerial photographic or digital sources may be used in the future.

The photography is scanned at an aperture which can be adjusted between 7.5 to 60 micrometers (microns), depending upon the scanning microdensitometer and desired output ground/pixel resolution. An aperture of approximately 25 to 32 microns yields a reasonable compromise between file size and adequate image resolution to support the present digital orthophoto program requirements. A 240- by 240-millimeter (9- by 9-inch) B&W aerial photograph scanned with an aperture of 25 microns yields approximately 92 megabytes of raw data. Using 1:40,000-scale photographs, a 25-micron scan equates to a ground resolution of 1 meter. A B&W quarter-quadrangle digital orthophoto generated and cropped from a 240- by 240-millimeter photograph, scanned at 25 microns, with the requisite overedge and header records produces a rectified file of approximately 55 megabytes.

1.5 DIGITAL ORTHOPHOTO STRUCTURE AND FORMAT

The archive and distribution format of the digital orthophoto file contains four ASCII header records, followed by a series of 8-bit, binary image data records. The digital orthophoto is cast on the Universal

Transverse Mercator (UTM) projection on either the North American Datum of 1927 (NAD 27) or North American Datum of 1983 (NAD 83) (See section 2.5). Digital orthophotos are archived and distributed so that when displayed on a computer graphics terminal, projection grid north is at the top.

For standard 3.75-minute digital orthophotos produced by the USGS and other Federal agencies participating under joint funding agreements and producers of digital orthophoto quarter-quadrangles participating under cooperative agreements with the USGS, the ground/pixel resolution is 1 meter. The resolution for the 7.5-minute digital orthophotos is 2 meters. Other ground/pixel resolutions may be produced to support other image requirements.

The geographic extent of the digital orthophoto is equivalent to an orthophoto quarter-quadrangle or quadrangle (3.75 or 7.5 minutes), plus sufficient overedge coverage to encompass the four primary and secondary horizontal datum corner points. The overedge consists of a range from between a minimum of 50 meters beyond the extremes of the primary and secondary horizontal datum corner points to a maximum of 300 meters beyond the extremes of the primary or secondary datum corner points, whichever is larger. The 300 meter overedge will be implemented by the USGS and other Federal agencies participating under Surveys, Investigations, and Research funding. The 50 - 300 meter overedge range standard exists to ensure that DOQs produced by entities other than the USGS meet a minimum overedge requirement. The resulting digital orthophoto is a rectangle, whose size may vary in relation to adjoining digital orthophotos. Figure 1-1 shows the relationship between the digitized image, ground control points, source DEM, source orthophoto, and 3.75- or 7.5-minute quadrangle corners. Figure 1-1 also illustrates the size difference between the scanned photograph and the digital orthophoto.

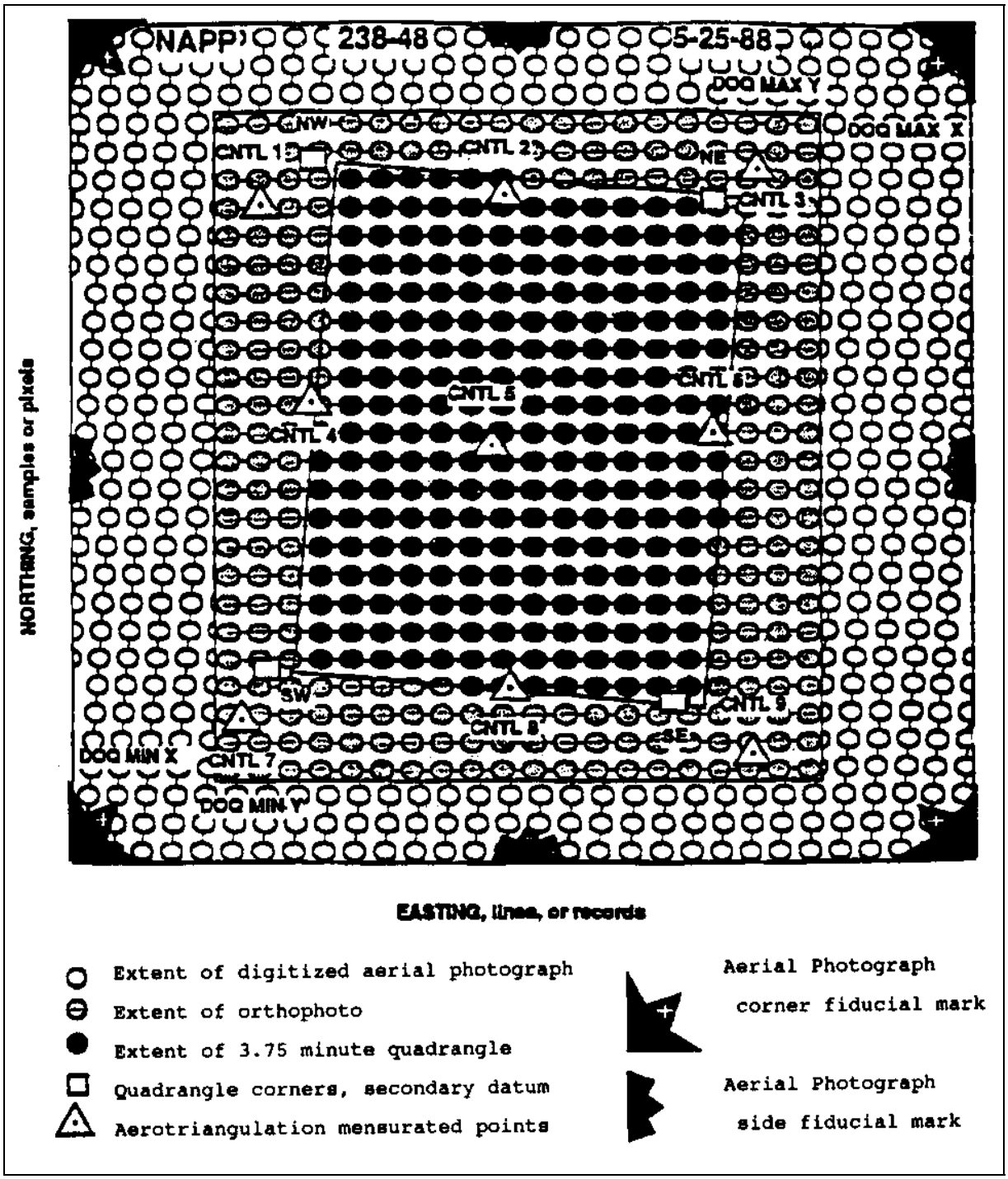

Figure 1-1
Sample 3.75-minute digital orthophoto data layout

References

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