National Spatial Data Infrastructure

National Digital Orthophoto Program

Development of a National Spatial Data Infrastructure (NSDI)

A critical component of the National Spatial Data Infrastructure (NSDI) is *Framework*. *Framework* provides a base on which to collect, register, and integrate geospatial information accurately and consistently. The Federal Geographic Data Committee (FGDC) proposed that *Framework* include geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral data. The Mapping Science Committee of the National Research Council recommends that geodetic control, orthoimagery, and elevation data become the critical foundation of the NSDI. The National Digital Orthophoto Program (NDOP) is a working model on how Federal, State, and local government, as well as private industry, can participate to develop the orthoimagery *Framework* for the Nation.

What is Digital Orthoimagery?

Digital orthoimagery is a digital representation of an aerial photograph or other remotely sensed data with ground features located in their true map positions. Displacements in imagery caused by camera tilt, sensor orientation, and terrain relief are removed. Digital orthoimagery combines the image characteristics of an aerial photograph or satellite scene with the accuracy and scale associated with a map.

Portion of Digital Orthophoto Quadrangle at approx. 1:18,000 scale

National Digital Orthophoto Program

Background—Following 25 years of analog orthophotography production, the use of digital orthophoto quadrangles (DOQs) has become one of fastest growing geo-technologies. Prototype and developmental products were produced and evaluated in the early 1990's beginning with the Dane County, Wisconsin, project. The concept of a National Digital Orthophoto Program was proposed in 1990 by the USDA-Natural Resources Conservation Service, Farm Service Agency, and the USDI-U.S. Geological Survey. Technical specifications for developing DOQs were finalized in 1993 and endorsed by the Base Cartographic Data Subcommittee of the FGDC. The NDOP began producing DOQs in 1993.

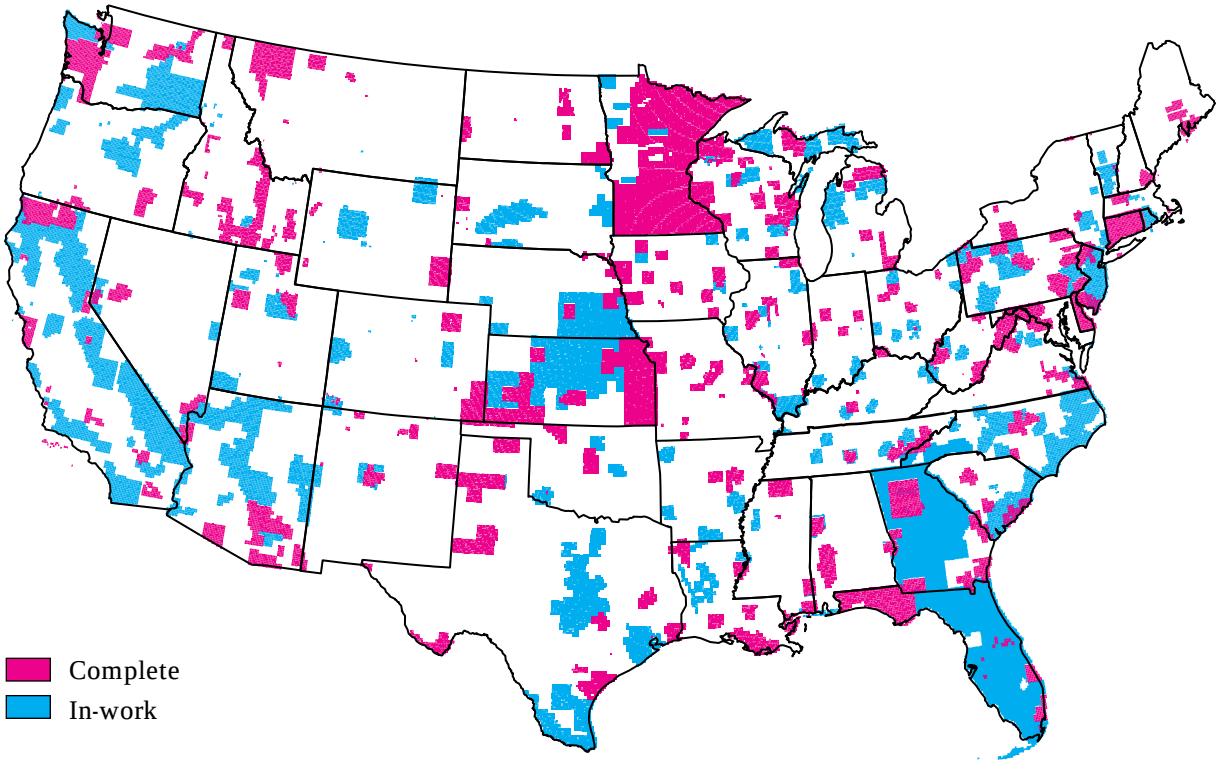
NDOP goal—The goal of NDOP is to produce DOQ coverage of the conterminous United States by the year 2002 through cooperative funding agreements with Federal, State, and local agencies. DOQs are planned to be updated on a 10-year cycle for most areas and a 5-year cycle in areas where land use change is more rapid. NDOP will attempt to accommodate regional, state, or local update schedules. The production strategy is to accomplish the majority of the work by contracting to the private sector.

Steering committee—The NDOP steering committee was chartered in July 1993 to provide program oversight and technical leadership for a national digital orthophoto program. The committee members represent the following agencies and organizations:

- Farm Service Agency
- National States Geographic Information Council
- Natural Resources Conservation Service
- U.S. Forest Service
- U.S. Geological Survey

The committee plans and coordinates program requirements, coordinates with the National Aerial Photography Program (NAPP) steering committee, coordinates the development of the Framework and NSDI with the FGDC, determines production strategies, reviews costs, monitors production schedules, develops and maintains technical criteria, develops cooperative agreements and partnerships with Federal-State-local agencies, keeps the public informed of the program and progress, and makes the data available to the public. Other Federal agencies wanting to participate in the program are invited to become members.

Program status—The NDOP has completed 28,906 DOQs, and currently have 33,911 DOQs in production. About 29 percent of the conterminous United States is either complete or in process as of May 1, 1996.



Digital Orthophoto Quad Status Map, May 1996

Digital Orthophoto Quad Production

DOQs are currently produced to a Federal standard using the processes and source data described below.

Aerial photography—NAPP is the primary source of aerial photography for DOQs. Flights are at 20,000 feet above mean terrain (1:40,000 scale) and flown in north-south directions with nominal 60 percent forward lap and 30 percent side lap. The imagery is either black-and-white or color-infrared. Photography exposures are centered on geographic cells covering 3.75 by 3.75 minutes of latitude and longitude. Several Federal and State agencies jointly fund NAPP to obtain complete conterminous coverage every 7 years. The acquisition of photography is contracted to the private sector. The NAPP steering committee provides guidance, and the U.S. Geological Survey administers the program. Federal agencies wanting to help acquire imagery of the U.S. are invited to become members of NAPP.

Ground control—Horizontal ground control necessary for producing DOQs is obtained by traditional field survey methods, Global Positioning System (GPS), or by precise stereoscopic transfer to the NAPP photography from existing photography. All control points must be photo-identifiable. General guidelines call for horizontal points must be spaced every 7.5 minutes around the perimeter of a project and at 15-minute intervals within the interior of the project. Horizontal ground control points are accurate to within 1 meter.

Aerotriangulation—Aerotriangulation (AT) extends or densifies control from the surveyed ground control by photogrammetric methods. Control is extended to produce nine control points located around the periphery and at the center of each photograph to be rectified. All ground and AT control for NAPP is generated in the Universal Transverse Mercator (UTM) coordinate system and on the North American Datum of 1983 (NAD 83). Theaccuracy of the AT points ensures that DOQs meet National Map Accuracy Standards for 1:12,000 scale products.

Digital Elevation Models—Digital Elevation Models (DEMs) are geo-referenced arrays of elevations spaced at regular intervals, generally 30 meters. The DEMs are used to remove image displacements caused by terrain relief during the rectification process. The elevation data and ground control are collected in the UTM-NAD 83 coordinate system.

Digital image scanning—NAPP photography is either black-and-white or color infrared and is scanned to produce bands with 8-bit resolution. The entire aerial photograph is scanned to capture the camera fiducial marks. The measured fiducial marks relate the digitized photograph to the airborne camera system. Scanning is usually done with a 15- or 30-micrometer aperture and yields file sizes of 55 to 235 megabytes for each band.

Digital rectification—Rectification is a three-step process. *First*, the camera is oriented to the plane of the earth using the x-y camera coordinates of the AT control and the X-Y-Z aerotriangulation coordinates. *Second*, the digitized image is registered to the camera using the measured image fiducial marks and the calibrated camera fiducial coordinates. These two steps produce two sets of transformation constants. The first is a matrix of rotation constants that is used to find the camera x-y coordinates of any ground X-Y-Z point. The second set is used to find the pixel coordinates of any x-y camera coordinate. The *third* step consists of sequentially progressing through the DEM and finding the correct pixels to put into the output geo-referenced grid.

Output products—The output product is a georeferenced DOQ with a 1-meter pixel resolution. A metadata header with information about the data set is an attribute bundled with the DOQ. Full resolution DOQs are available in soft copy on 8 mm tape and a compressed format on CD-ROMs. Hard copy graphic copies are not distributed; however, DOQ users have the option to produce their own low-cost hard copies (300 to 600 dpi) or obtain high-quality copies (1,200 to 2,500 dpi) from private contractors.

Technical Characteristics of a DOQ

- Source imagery—NAPP black-and-white or color infrared.
- Photo scale 1:40,000.
- Digital black-and-white or color infrared.
- DOQ uncompressed file size—approximately 55MB per band.
- Compressed format—JPEG, 5MB per DOQ.
- Georeferenced with 1.0 meter ground sample distance.
- Meets National Map Accuracy Standards for 1:12,000 scale (± 33 feet).
- Image overedge beyond neatline—50 to 300 meters.
- Bands stored in 256 gray level values.
- UTM coordinate system—NAD 83 datum.
- Centered on 3.75' x 3.75' geographic cell.
- Ancillary product is the DEM.
- DEM is equal to or better than a level one DEM with an RMSE of no greater than 7 meters.
- DOQ metadata header is FGDC compliant.
- Published technical specifications.
- USGS sells a soft copy only.
- Archived as part of the NSDI *Framework* data base.

A National Digital Orthoimagery Standard

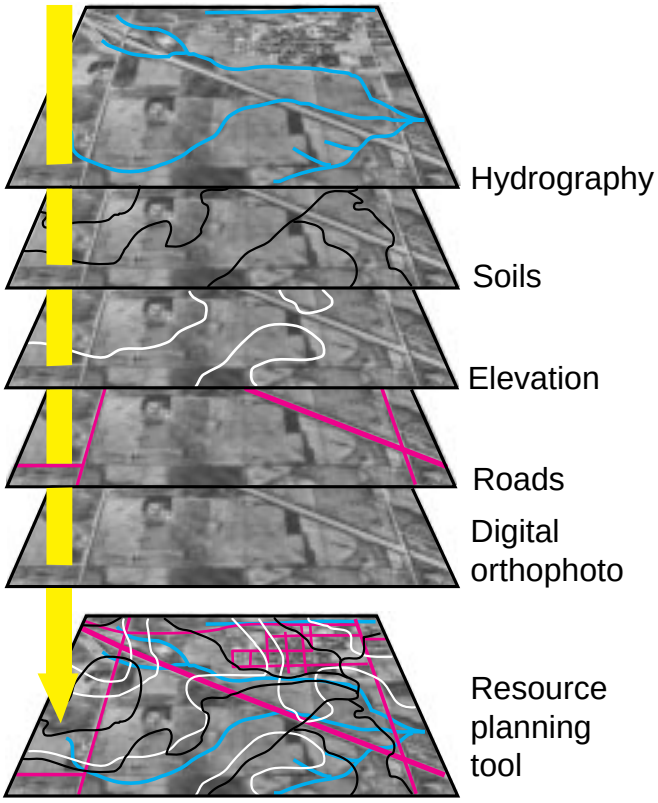
The FGDC is sponsoring the development of a National standard for digital orthoimagery. The objective of this standard is to promote data sharing and eliminate redundant production where possible. The standard will undergo public review and comment, early in 1997, with the intent of including the broadest range of potential data producers and users in the development process. Areas addressed by this standard will include: digital orthoimage structure, sources, georeferencing, resolution, accuracy, and data quality. The NDOP DOQ standard will be compliant with the FGDC National Standard.

Applications of DOQs

DOQs support a variety of GIS and mapping applications and offer several advantages over the traditional line base map. DOQs are used to develop and/or revise vector files of transportation, cadastral, and land use/land cover information. Federal, State, and county agencies use DOQs as a base map for wetlands, soils, land parcels, farm-field boundaries, forest inventory, and other natural resource mapping, analysis, and planning applications.

Users have experienced the following advantages and benefits of using DOQs:

- The DOQ provides the organization and GIS users a common image base map for inventorying, digitizing, and analyzing different types of geospatial information.
- Developing geospatial data referenced to an accurate and standardized DOQ facilitates the sharing of data, fosters collaborative projects, and reduces the need to duplicate the high cost of data base development.
- The DOQ contains more land features than a line map.
- On-screen digitizing and updates to land use and land features are done directly off the computer monitor.
- In comparison to a line map, the DOQ costs less to develop and update and takes less time to produce.
- Users can make accurate measurements of distances, positions, and areas from DOQs.
- The x-y ground coordinates of each pixel in the image can simply be determined.
- The DEM can be used in conjunction with the DOQ for various slope and aspect analyses.
- DOQs can be rescaled to meet user needs.
- Landowners and clients can interpret a DOQ image as a picture of the landscape and gain a visual understanding. DOQs can be digitally mosaicked, re-sampled, and merged into a single image of a larger area.



DOQ Used as Framework for Geospatial Data

Federal-State-Local Partnerships

Objective—The NDOP steering committee encourages cooperative production arrangements with other organizations for the purpose of increasing the extent of national DOQ coverage and the currentness of the public domain holdings. NDOP desires to include as many organizations as possible into the national program and leverage funds to the fullest extent among contributing organizations.

Policy—The committee member organizations, will actively seek cooperating partners for every project, and will equitably share production costs with these partners, either through contributed funding or work-in-kind services.

Implementation—The committee members will use the following guidelines to establish cooperative partnerships with other organizations:

- DOQs will be produced cooperatively to the extent that the NDOP members have funds or resources to match cooperators.
- Members will cooperate on projects that comply with their missions and programs of work and comply with, or achieve through additional processing, the Federal standard for DOQs.
- Committee members may cooperate independently with other organizations for selected projects, rather than cooperating as a single entity.
- To maximize funding leverage, the committee seeks to include as many partners as possible in each project or program of work.
- To maximize funding leverage, the committee gives highest priority to cooperative arrangements wherein all partners share equally in contributing to the production.
- The committee will participate in arrangements of unequal contribution negotiated to the satisfaction of all participants, but arrangements of unequal contributions may hold less priority than arrangements of equal contributions.
- To clarify the definition of partner with respect to States, NDOP views a State Mapping Advisory Committee (SMAC) or State GIS Council as a single entity for cooperating purposes, representing all State interests. If State agencies operate independently with respect to data acquisition and management, then the NDOP considers each of those organizations to be separate entities and, therefore, separate partners in an agreement.
- NDOP will approve the USGS "Fixed Price Schedule" for determining the value of products to be produced cooperatively and the value of work-in-kind services performed as contributions.

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Online Status

Information and status of NAPP and DOQ available from these internet sites:

Map status by quarter quad:

ftp www-nmd.usgs.gov
Name: anonymous
Give your complete email address as password
cd/pub/dpi/doq_status
File name for list of completed DOQs: doqcom.txt
File name for list of in-work DOQs: inwork.txt

View the DOQ status map:

ftp://www-nmd.usgs.gov/pub/doi_high_priority/html/doq_stat.htm

http://www.ftw.nrcs.usda.gov/ortho.html
Click on "Status of Digital Orthophoto Quads"

DOQ Brochure: *(Need Adobe Acrobat Reader installed to view)*

http://www.ftw.nrcs.usda.gov/nsdi_node.html
Click on "National Digital Orthophoto Program"

Purchasing DOQs:

http://www-nmd.usgs.gov/esic/esic_index.html
This is a list of USGS sales offices.

Phone: 1-800-USA-MAPS

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