FORUM ON ORTHOPHOTOGRAPHY

NASA GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

MAY 15, 1990

SUMMARY REPORT
FORUM ON
ORTHOPHOTOGRAPHY

SUMMARY
REPORT

FORUM CO-SPONSORED BY THE:

U.S. Soil Conservation Service
U.S. Geological Survey
National Governors' Association
National Association of Counties

U.S. Geological Survey
Reston, Virginia
1990
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APPENDIXES

A. Co-Sponsoring Agencies and Cooperating Organizations

B. Organizational List of Forum Registrants

C. Forum Registration List

D. Orthophoto Products Survey
A Forum on Orthophotography was held on May 15, 1990, at the National Aeronautics and Space Administration's Goddard Space Flight Center in Greenbelt, Maryland. The forum was sponsored jointly by the U.S. Soil Conservation Service, the U.S. Geological Survey, the National Governors' Association, and the National Association of Counties.

The purpose of the forum was to expand the understanding and use of orthophoto products among the user community, as well as among those currently considering, or as yet unfamiliar with, the use of these products. It was also intended to provide a forum for assessing requirements for, and interest in, orthophoto products and for the identification and discussion of issues and future needs concerning orthophoto use and coordination.

The 1-day forum was organized into three major sessions that focussed on technical aspects, user applications, and management issues. The first session presented a brief background and overview of the technical characteristics of standard and digital orthophotos. The second session included formal presentations by Federal, State, and county government agencies on their current and planned applications of orthophoto products, with particular emphasis on their use within geographic information systems. In the third session, private industry addressed their community's interest, capabilities, and potential role. This session also included a proposal by the U.S. Soil Conservation Service for a national cooperative program for the production of 1:12,000-scale orthophotoquad products. In addition to the formal presentations, the forum provided a time for open discussion in which attendees had an opportunity to exchange information and make statements about their needs or other items pertinent to the production and dissemination of orthophoto products. Several agency orthophoto product exhibits and interactive demonstrations were also available throughout the day.

This report includes a forum agenda and summaries of the various presentations given by the program participants. The appendixes to the report include a list of forum co-sponsoring agencies and cooperating organizations, a summary listing of forum registrants by organizational affiliation, and the forum registration list. Also included in the appendixes is the Higher Resolution Orthophoto Products Survey that was sent to each participant following the forum to assist in the identification of near- and longer-term applications, and the determination of requirements, for higher-resolution orthophoto products.
FORUM AGENDA

FORUM ON ORTHOPHOTOGRAPHY
MAY 15, 1990

7:30 Registration

BACKGROUND
8:45 National Aerial Photography Program (NAPP)  Don Light, NAPP Interagency Steering Committee
9:45 Break

APPLICATIONS
10:00 Panel: Federal Agency Applications
  • Soil Conservation Service  Lane Price
  • Agricultural Stabilization and Conservation Service  Ronald Dickson
  • Geological Survey  Alan Mikuni
  • Fish and Wildlife Service  William Wilen
  • Bureau of Land Management  Michael Hutt
  • Forest Service  Peter VanWyhe
  • Department of the Navy  Marge Elliott
11:45 Discussion
12:00 Lunch
1:15 Panel: State and County Applications
  • California  David Kehrlein
  • Maryland  William Burgess
  • Minnesota  George Orning
  • Dane County, Wisconsin  Stephen Ventura
  • National Organization Perspective  Yogendra Singh
- National Association of Counties
2:30 Discussion
2:45 Break

MANAGEMENT ISSUES
3:00 Soil Conservation Service Proposal for a National Cooperative Program  Gale TeSelle, Soil Conservation Service
3:30 Private Sector Perspective: Needs, Resources, Role  Bryan Logan, Photo Science, Inc.
4:00 Open Discussion
5:15 Wrap-up
## SUMMARY OF PRESENTATIONS

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The National Aerial Photography Program (NAPP) is jointly funded by Federal agencies with contributions from States that participate in the program. The NAPP is designed to acquire black and white (B&W) or color infrared (CIR) photography at an altitude of 20,000 feet above mean terrain. The program utilizes 6-inch focal length cartographic mapping cameras that produce photography at a nominal scale of 1:40,000. An overview of NAPP flying, now going into its 5th year, and the National Plan to cover the 48 States every 5 years, is presented. The resolution and geometric quality of the photography associated with the flight parameters are described to estimate the system's capability to produce image maps, digital elevation models, and topographic maps at 1:24,000-scale to meet national map accuracy standards. Also, a technique is presented that computes the optimum scanning spot size (15um) for converting the B/W or CIR photography to machine-readable form which can be useful in a geographic information system or in making digital orthophoto image products.
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CHARACTERISTICS OF STANDARD AND DIGITAL ORTHOPHOTOS

Lyman Ladner
U.S. Geological Survey

An orthophoto is by definition "a photographic reproduction prepared from perspective photograph in which the displacement of images due to camera tilt and terrain relief have been removed" (Manual of Photogrammetry, 1966). The definition may be expanded to include "so that the orthophoto has the same metric properties as a map and it also has a uniform scale."

The USGS designed and constructed the first working orthophotoscope, the T-64, in the late 1950’s. This instrument was the first functioning orthophoto production instrument. The T-64’s were used at Western Mapping Center (WMC) for many years but were replaced by the Wild PPO-8 orthophotoscope and the Wild OR-1 orthophoto scanner.

In 1986 the WMC Research and Development Office proposed a research project to develop software to produce a digital orthophoto. Software development has proceeded at a steady pace.

The basic equipment necessary to make a digital orthophoto are a scanning microdensitometer and a digital computer. A scanning microdensitometer is a precision instrument that uniformly scans a photograph in a rectilinear fashion so that the designated area is completely covered by adjacent picture elements (pixels) of the desired size. A single numerical value is assigned to each pixel proportional to the photon flux at that point (Horton, 1978). The entire aerial photograph is digitized resulting in a data volume of from 20 million bytes for a 50-micrometer pixel size to slightly over 80-million bytes with a 25-micrometer pixel. Consequently, the computer required to process these large data sets must be fast, have a large random access memory, and have large data storage devices.

The input data needed for the realization of a digital orthophoto are:

A digitized image, a digital elevation model (DEM), and both interior and exterior photo orientation parameters. Control for the aerial photograph is developed by routine aerotriangulation methods. The diapositive to be scanned is placed on the microdensitometer and digitized. The digital data is written to tape. The data is then processed using the software developed at WMC. The result of this process is a digital image that can be used as an image map base in a graphic display system or written to film to form a hard copy orthophoto.

Applications for digital orthophotos are limited only by the capabilities of the related technologies.
THE POTENTIAL USE OF 1:12,000-SCALE ORTHO QUARTERQUAD NAPP IMAGERY IN THE USDA SOIL CONSERVATION SERVICE

Lane Price
U.S. Soil Conservation Service

The missions of the USDA - Soil Conservation Service (SCS) is to assist the land users of the U.S. to conserve their soil, water, and related natural resources. Through approximately 3,000 field offices, conservationists assist farmers, ranchers, developers, homeowners, industry, and other government agencies, to plan and implement resource management systems. To provide this assistance, SCS operates several major programs: Conservation Operations (technical assistance, soil surveys, snow surveys, and plant materials programs), River Basin Surveys and Investigations, Watershed Planning and Flood Prevention Operations, Great Plains Conservation Program, Resource Conservation and Development, and a National Conservation Program.

To carry out these programs, SCS requires access to diverse geographic databases, most of which do not currently exist in digital form. A primary role for 1:12,000-scale ortho quarterquad (OQQ) products will be to serve as a national map base for the development of digital geographic data layers for use within SCS and by other agricultural and non-agricultural users.

To accurately deal with field-sized areas, the agricultural community requires a scale such as 1:12,000. The use of this scale may also facilitate the multiple use of the digital data by local governments who often find 1:24,000 scale digital data inadequate. The existence of a single map base will allow agencies such as SCS and ASCS to share not only tabular data but also geographic data to conduct coordinated programs as required by the Food Security Act of 1985.

The primary geographic data layers which will benefit from a 1:12,000-scale OQQ program are: soil surveys, farm/field boundaries, wetlands, agricultural features (farm locations, concentrated livestock sites, wells, irrigation sites, and the location of certain conservation practices), resources inventory sample points, land cover and use, and soil type description sites.

To provide the ability to quickly perform complex spatial analysis of this data, SCS is implementing a strategy to utilize geographic information system (GIS) technology. A major component of SCS's implementation strategy is to put the GIS (GRASS) in the hands of the planner. Perhaps the greatest difficulty to implementing GIS in the SCS field office is the lack of computer and GIS expertise. To facilitate local digitizing of data, SCS is also interested in handling the OQQ imagery digitally in optical disk format, to provide an intuitive user interface for digitizing on the screen, and using the imagery as both screen and hard copy backdrops to the Conservation Plan Maps provided to our Cooperators.
The Agricultural Stabilization and Conservation Service (ASCS) is the agency of the U.S. Department of Agriculture that is responsible for administering a variety of commodity and land-use programs aimed at stabilizing farm prices, adjusting farm production, conserving natural resources, and protecting the environment. Programs are administered through a network of State and County offices. With 2,800 local offices, ASCS employees serve farmers in 3,054 agricultural counties throughout the United States.

Aerial photography has been an important tool in the administration of farm programs for the past 55 years. Enlargements, photographically rectified to the scale of 660 ft./in., are used to identify land boundaries in terms of farms, tracts and field; measure acreage and record usage for each crop season.

The specialized aerial photography products used for ASCS programs are provided to each of the 2,800 county offices by the Aerial Photography Field Office (APFO) in Salt Lake City, Utah, on an average cycle of about 7-1/2 years. In order to maintain this cycle, the APFO processes new photography for an average of seven ASCS counties each week.

In order to produce enlargements that are scale accurate within ASCS' tolerance of +/− 1 percent, the APFO uses a specialized system of analytical aerotriangulation designed to compute rectification parameters for large volumes of aerial photography. Rectification parameters are computed in terms of center scale at the principal point of each exposure and a north-south, east-west vector of tilt necessary to best obtain the same scale throughout the area covered by each exposure.

Rectified enlargements are made on custom designed, automated, rectifying enlargers. The standard format used by ASCS to make 660 ft./in. enlargements on 24" x 24" paper is a left and right sectional of the center portion of each consecutive exposure in the line of flight.

In the event that there are cropland areas on an enlargement that lie at elevation differences so that the difference in scale exceeds ASCS tolerances, more than one enlargement of that area is made, each representing cropland at a different elevation. The use of orthophotography in these areas, where there is cropland on one exposure at elevation differences exceeding 300 feet, would be beneficial to ASCS.

In the county office the enlargements are used to identify annual usage by farm, tract within a farm, and fields within a tract. When changes take place that affect the official acreage assigned to a field, acreage is measured through use of a digital planimeter specially programmed for ASCS applications.
In order to update land use information each year, the ASCS records are updated using 35mm slides acquired by the counties at the appropriate time to best capture cropland usage information. In the event that field lines differ between the enlargements and the current 35mm slides, the digital planimeter is designed to make measurements directly from the projected image of the 35mm slide. Orthophotography would serve well as the base from which to derive proper measurements from the slide imagery.

ASCS is studying the feasibility of using a digital imagery medium in county office applications. Such a system would require a relatively dense network of control points. Orthophotography could provide the medium from which to extract random control at the density and accuracy required for ASCS use.
ORTHOPHOTO APPLICATIONS AT THE U.S. GEOLOGICAL SURVEY

Alan Mikuni
U.S. Geological Survey

The National Mapping Division (NMD) of the U.S. Geological Survey has responsibility for the conduct of the National Mapping Program, which includes the Primary Map Series. The orthophoto, although not specifically a component of that series, is widely accepted in the map-using community as a cost-effective and up-to-date product of the USGS. Through production of orthophotos (sometimes referred to as orthophotoquads or OQs), the NMD is able to respond to urgent user requirements for base map data in areas unmapped by conventional 7.5-minute standard topographic quadrangles, or for other special purposes.

Although recognized as a producer of orthophotos for other users, the USGS has significant requirements of its own. In managing the National Mapping Program, a primary focus of which is the completion of the 7.5-minute, 1:24,000-scale topographic map series for the U.S., the NMD uses and plans to continue to use orthophotos in the production and revision of those maps.

In the current map production process, the USGS uses orthophotos in the preparation of the U.S. Public Land Survey Systems map separate. The scale- and distance-accurate nature of the orthophoto provides a very stable base upon which to retrace the original surveys of Bureau of Land Management (formerly General Land Office-GLO) land surveyors. Through the use of imagery shown on orthophotos and distances and bearings from the BLM and GLO field notes, the surveys are plotted and field searches for original monuments planned. The USGS uses recovered monuments to develop the final land net for its published base maps.

Following completion of the once-over coverage of the United States with base maps, the USGS will concentrate on revision of the vast inventory of graphic maps and derivative digital data files. Digital data in the National Digital Cartographic Data Base, which are collected from the graphic maps, will be revised on advanced cartographic systems that compare digital imagery with the existing digital line graphs and permit edits of the data. Digital orthophotos, derived from National Aerial Photography Program imagery, and appropriately scaled and datum- and projection-adjusted, provide a suitable image source for digital revision. The Western Mapping Center of the USGS has recently combined a digital orthophoto and a DLG in an existing workstation and performed revision of selected features.

Higher-resolution orthophotos over-printed with existing line-map data provide a highly detailed representation of map data requiring deletion, addition, or modification in the graphic map revision process. The higher-resolution image data may reduce the need for costly field work. Orthophotos used in the map revision process would also be available to the map using public.
In 1974, the U.S. Fish and Wildlife Service directed its Office of Biological Services to design and conduct an inventory of the Nation’s wetlands. The mandate was to develop and disseminate a technically sound, comprehensive database concerning the characteristics and extent of the Nation’s wetlands. The purpose of this database is to foster wise use of the Nation’s wetlands and to expedite decisions that may affect this important resource. To accomplish this, state-of-the-art principles and methodologies pertaining to all aspects of wetland inventory were assimilated and developed by the newly formed project. By 1979, when the National Wetlands Inventory Project (NWI) became operational, it was clear that two very different kinds of information were needed. First, detailed wetland maps were needed for site-specific decisions. Secondly, national statistics developed through statistical sampling on the current status and trends of wetlands were needed in order to provide information to support the development or alteration of Federal programs and policies.

The Emergency Wetlands Resources Act of 1986 directs the Secretary of the Interior, through the Director of the Fish and Wildlife Service, to produce by September 30, 1990 and at 10-year intervals thereafter, reports to update and improve the information contained in the report entitled "Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's." The Act also requires the Fish and Wildlife Service to produce, by September 20, 1998, National Wetlands Inventory maps for the remainder of the contiguous United States and, as soon as practicable, wetlands maps for Alaska and noncontiguous portions of the United States.

The National Wetlands Inventory has produced wetland maps married to USGS large scale base maps for 65 percent of the lower 48 States, 20 percent of Alaska and all of Hawaii. When the mapping is complete approximately 60 percent of the bases will be orthophotoquads.
The Bureau of Land Management (BLM), an agency of the U.S. Department of the Interior, manages approximately 272 million acres of public lands--about one-eighth of the land in the United States--and the mineral estate underlying another 300 million acres of lands administered by other government agencies or owned by private interests. Public land resources managed by BLM include rangeland, timber, minerals, watershed, fish and wildlife habitat, wilderness, recreation, and archaeological sites. The Bureau is also tasked with establishing and maintaining the Public Land Survey System (PLSS) and its associated records.

The BLM currently uses rectified images stratified by spectral band (panchromatic or multispectral), resolution and media format (hard copy or soft copy). The USGS 7.5 minute orthophoto is the most commonly used image map in the BLM. It is estimated that 75 percent of the resource data currently digitized into the BLM's geographic information system (GIS) were initially delineated using an orthophoto as the base. Soil types, vegetation classifications, transportation networks, oil and gas pad locations, riparian zones and miscellaneous cultural features are examples of GIS data which were originally compiled using an orthophoto base. BLM specialists also use orthophotos as a field aid in searching for PLSS monuments, as a tool to communicate land management practices, to resolve land and resource use conflicts, to monitor surface compliance actions, for fire fighting activities, and as inserts to Environmental Impact Statements and Resource Management Plans.

Sound resource management practice demands that BLM managers constantly update and maintain their GIS database information. The evolution of spatial data processing has reached the point that using a digital image to create and maintain GIS databases is technically and economically feasible. The BLM supports the concept of a national digital image program. The development of such a program should address the following options and associated costs:

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<td>1/4 QUAD</td>
<td>7.5 MINUTE QUAD</td>
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<tr>
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<td>NAPP</td>
<td>MOSAICKED LEVEL I</td>
<td>SATELLITE</td>
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<td>10-30 METER</td>
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<tr>
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<td>YES</td>
<td>YES</td>
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<td>CYCLE</td>
<td>5-10 YEARS</td>
<td>5-10 YEARS</td>
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USDA FOREST SERVICE ORTHOPHOTOGRAPHY PROGRAM

Peter VanWyhe
U.S. Forest Service

The Forest Service (FS), U.S. Department of Agriculture, manages National Forests and Grasslands under the multiple use-sustained yield philosophy. Under sustained yield no more can be taken from the land than it can continue to produce in the long term.

The National Forest System consists of 156 National Forests on 191 million acres—8.3 percent of the United States. There are National Forests in 42 States and Puerto Rico. Half of the cold water fisheries are on National Forest lands. Half of the big game animals, 80 percent of elk, live on the National Forests. Nearly 80 percent of all Wilderness Areas outside of Alaska are on National Forest lands. The FS provides 40 percent of all Federal recreation use, twice as much as the next Federal agency. It has the largest trail system in the Nation, more than 108,000 miles for hiking, riding and cross-country skiing. Over 70 percent of the Wild and Scenic River system in the lower 48 States is on National Forest land. Half of the Nation's inventory of softwood sawtimber is on National Forests. Minerals found on FS lands provide $3.5 billion in private sector revenue, and FS activities support 500,000 private sector jobs.

Does the Forest Service use orthophotography to support all of this...YOU BETCHA, and lots of it. This fiscal year to date our Geometronics Service Center (GSC) in Salt Lake City has produced more than 1,400 ortho projections at 1:24,000 scale using both 1:40,000 and 1:80,000-scale photography, and 1:31,680 scale in Alaska from 1:80,000-scale photography. This has been accomplished using both United States Geological Survey (USGS) and Forest Service produced Digital Elevation Models in a double shift production schedule. Production is on the Wild OR1.

The Geometronics Service Center's normal production is 1,100 ortho projections a year but with increases in computer use in resource management and with geographic information systems coming into wider use, we have seen an increase in demand for orthophotography. Even with increased production we cannot meet demand. At least two Regions have ordered SPOT source rectified image products because they need ortho products faster than standard production methods and capacity can generate them. The Geometronics Service Center is on the second cycle of orthophoto production in some areas.

The GSC prefers 1:80,000-scale National High Altitude Photography to produce the 1:24,000-scale ortho products. There has been some work with the 1:40,000 scale photography. Using the 40,000-scale photography has had a production impact. It takes about 2 to 2 1/2 times longer to project orthophotos from 1:40,000 photography to cover a full 7.5-minute quad area. In addition, the aerotriangulation workload is increased about four times.

Demand for orthophotography is increasing in all areas. Though most of our demand has been in the western U.S., we have coverage in Puerto Rico and demand is increasing in the eastern U.S.
Unbeknownst to many, the Department of Defense (DOD) strives to take a proactive role when it comes to many environmental compliance issues. Biologists, ecologists, archaeologists, planners, environmental protection specialists, and other DOD scientists and engineers are attempting not only to achieve environmental compliance, but also exceed requirements through environmental enhancement actions.

Many DOD military installations are extensive in area, and may be characterized by multiple land use activities on a variety of land cover types. Environmental compliance requirements are numerous and complex, ranging from cultural and natural resource management to pollution abatement, hazardous waste minimization, hazardous waste management, installation restoration and military master planning. Fulfilling environmental program objectives while meeting military mission requirements poses a unique challenge to the DOD environmental manager, particularly when staff and available resources are limited.

Maps and aerial photographs have long been important to the DOD environmental specialist as planning and communication tools. Typically, maps and photographs used by DOD are derived from multiple sources at different scales, depending on project-specific requirements. When integration of data is required, it is often difficult and costly for environmental specialists to rescale or recompile maps and photographs. It is even more difficult to integrate important non-graphic data such as bird counts, monitoring well data, or historic site inventories with traditional map and photo products for environmental compliance reports or decision-making documents.

Recent trends in digital mapping of DOD facilities have provided some relief to this problem of environmental information integration. An increasing number of DOD facilities are being mapped using computer-aided design (CAD) systems which can generate vector maps suitable for overlay and integration of environmental information. Aerial photo or image data, however, are still not easily integrated with the vector-based maps being generated by traditional CAD systems within DOD.

Digital orthophoto technology offers tremendous potential benefits to DOD environmental and facilities managers, particularly when combined with emerging systems capable of "hybrid" raster and vector mapping and image processing functions. One such system readily available to DOD and other Federal agencies is "GRASS", the Geographic Resources Analysis Support System developed by the Construction Engineering Research Laboratory (CERL) in Champaign, Illinois.
Since many tasks associated with environmental management require a combination of map accuracy and aerial photographic detail, high resolution digital orthophotographs can provide an important platform for environmental information integration. Potential applications of digital orthophoto technology in support of DOD environmental compliance programs are illustrated in the slides accompanying this presentation. These include wetlands mapping, facilities planning, natural resource management, archaeological field survey, and environmental restoration applications.

Actual color digital orthophoto data recently acquired from USGS are also shown, after processing on an Intergraph TIGRIS workstation, courtesy of Intergraph Corporation, Huntsville, Alabama. The processed data, covering portions of the Williams and Indian Springs, Indiana quadrangles, demonstrate the high degree of map accuracy and image detail offered by digital orthophotographs for map updating and environmental feature extraction. As these types of data and systems become more readily available to the DOD environmental manager, it will become increasingly easier to integrate field, laboratory, image, and map data to achieve environmental compliance and enhancement.
A quick flight over the L.A. basin and surrounding mountains courtesy of satellite imagery and computer animation, brings to life California’s intense urbanization amidst extreme topography, earthquake faults, and other natural and manmade hazards. California is at risk for fire, earthquake, flood, mudslide, volcano, and drought on an almost continual basis. To better deal with these problems, the State Office of Emergency Services in conjunction with the FIRESCOPE program have purchased several thousand 1:24,000-scale orthophotoquads over the last few years.

These orthophotoquads have many specific uses. Firefighters are interested in vegetation and unmapped roads and structures. Rescue teams are looking for probable travel routes, and a hazmat team may want to identify individual buildings and fixtures that may be obscured by fog or smoke. Many times more information may be imparted by an orthophotoquad than by an excellent line map.

There are several issues that must be addressed before a full digital orthophotoquad program can be undertaken. Recency is extremely important in a fast growing State like California, especially in the Urban Interface areas. A scale no smaller than 1:12,000 is necessary to support response level units. In terms of computer processing and storage capability, high speed computers and storage of at least several hundred gigabytes is required. Cost is of paramount importance, so cost sharing possibilities must be researched to the fullest.

Just as a simulated flight can enhance our view of the L.A. basin, so could a digital orthophotoquad of a disaster area. With the unusually high number of risks in California, this has become a high priority. Although there are many problems to overcome, I believe that most of the elements of a continuously developing orthophotoquad program are falling into place. We must all work together to construct the cost sharing environment to support such a program.
MARYLAND'S DIGITAL MAPPING AND ORTHOPHOTO PROJECTS

William S. Burgess and K. Peter Lade
Maryland Department of Natural Resources and Salisbury State University

The Maryland Department of Natural Resources, Water Resources Administration, and the Image Processing and Remote Sensing Center at Salisbury State University are working in partnership to provide a new series of nontidal wetland guidance maps for the State of Maryland and to develop high resolution base maps using digital orthophoto methods. The initial base maps were prepared from 10 meter panchromatic digital SPOT satellite imagery by extricating and rotating segments representing the same spatial area as the USGS 7.5-minute map series for the State. The delineation of nontidal wetlands comes from existing National Wetland Inventory Maps that were digitized by the U.S. Fish and Wildlife Service. Each wetland type was plotted into the image in a different color with special emphasis on locations of rare, threatened and endangered species as well as unique habitat areas. Additional information was added in the form of shorelines, streams, roads and place labels that were purchased from a private source and from TIGER files. Maps are printed at a scale of 1:24,000 using a 400 dpi color electrostatic printer. They are currently available from Salisbury State University. Digital files that are linked through a hyperindex system will be available this summer after contractual agreements and royalty payments are made between the State and private vendors of the data.

A second generation of digital orthophoto base maps and overlays will address the need for higher image resolution and new more accurate interpretations of wetlands as required for full implementation of Maryland's Nontidal Wetlands Protection Act. A pilot project was begun in 1989 to determine the feasibility of using digital color orthophoto quarter quads. Photo Science, Inc. was contracted to provide digital files and mylar products representing the NW and SW quarters of the Millington, Maryland quad using existing NAPP color infrared photography. They provided the digital file to MicroImages, Inc. for conversion to a file format that is currently in use by the Water Resources Administration. Additional work was performed to develop full color printer drivers for the 400 dpi electrostatic printers to output a prototype print. The project has proven the overall feasibility of producing digital orthophoto quarter quads for use on personal computer systems. The principal lessons learned are that scan rates must be as high as possible (approximately 25 microns) and that color infrared imagery can provide suitable color and grey scale map products for use in automatic delineations of land cover, forest type, etc. Mylar products will be produced at a scale of 1:12,000. Digital images will be dense enough to print at scales down to 1:2,400 in full color or grey scale. This map series is expected to provide a suitable base for many mapping applications in Maryland and will allow map accurate overlay information to be developed. Several "spin-off" modeling efforts are anticipated that will use the full power of such a map system. These maps will also foster convenient transfer of accurate information between different GIS systems based on raster and vector applications allowing for full use of the strengths of each type of system. The State expects to use the strawman standards proposed by the SCS for the production of initial maps (except the scan rate) until a firm Federal standard becomes available.
HISTORY

Minnesota has a long history of support for coordinated statewide air photo efforts. In the late 1960s the State, in cooperation with the University of Minnesota and a private contractor, flew the entire State and produced a set of high altitude photos and blueline reproductions of each 1:24,000 quad sheet area. The photos were used as the data base for the production of a land use map. The map was produced by a statewide geographic information system structured by 40 acre parcels.

In the late 1970s high altitude flight was repeated and a new set of quad based blueline photos were produced. Over 1/4 million separate blueline quad sheet reproductions have been used internally by State agencies for planning and administrative work.

FUTURE

In the future there will be an increased need for these types of products. We are entering an era of more intense resource use, and the uses are more intermixed. For example, our lake regions in the forested areas are being much more intensively used for lumber production. As a result, we need to set priorities for resource use and preservation.

As we discover more interaction between different land areas and better understand the complex resource land use relationships within each use, our need for information increases. In most cases these relationships call for coordination and interdisciplinary approaches to decisionmaking, hence the need for integrated data bases, both photographic and computer. The ability to share and compare information is crucial.

The data needs to build on the existing mapping system so the United States Geological Survey quadrangle sheets are the logical choice. The program ties in well with existing inventory efforts by forestry, land use update, and the well-developed urban county based and State based geographic information systems.

Orthophotos are important because of the inclusive nature of an orthophoto map product. They are the best tools to see what is there and they are not human-dependent for interpretation to a map to be passed on through many sources. With much interdisciplinary use this is important because of the different perspectives offered by each user group or discipline.

Orthophotos may become more important in the future because of the expected continued improvement in geographic information systems' ability to enter, store and manipulate data. Orthophotos will be scanned in and through analysis routines create many complex data sets that will help us analyze resource conditions and use, and update the many time series information systems needed to manage our resources and monitor their condition.
The CONSOIL project began in 1987 to examine the use of spatial information technologies for implementing conservation provisions of the 1985 Federal farm bill (Food Security Act of 1985). The project is a cooperative effort between several Federal, State, and local agencies, along with the University of Wisconsin-Madison. Soon after the inception of the CONSOIL project, participants were asked by Soil Conservation Services’s Cartography and Geographic Information System Division (SCS-CGIS) to help evaluate prototype 1:12,000 quarter-quadrangle (3.75-minute) centered orthophotography (OQQs). SCS-CGIS hypothesized that such products could result in accuracy and efficiency improvements in spatial data management at local field offices of Federal agricultural agencies. SCS-CGIS and CONSOIL participants also thought there would be many other uses for such products.

Research on the first hypothesis has been integrated into the overall CONSOIL agenda. The use of orthophotography in the Dane County USDA field offices has been part of an automated spatial information system implementation process. To determine whether the OQQs had broader uses, agency personnel in the Madison vicinity were surveyed to determine their opinions about the form and use of the products.

Conservation Field Office Use

Since before the inception of the 1985 Food Security Act, the Dane County Land Conservation Department has used some form of automated geographic information system (GIS). They work side-by-side with the USDA-SCS, putting this local field office far ahead of most of their counterparts across the country in terms of GIS implementation. Because a relatively sophisticated GIS had already been implemented by the time the OQQs were available for Dane County, they were examined in that context, not in the context of providing a base for GIS implementation, as is likely to be a more typical situation across the country. Because data sets such as farm tracts and fields had already been automated, and because the products were not delivered in time to be used for farm bill mandates, the OQQs were not used to the full extent possible. The field office agencies are now making a transition to the more accurate OQQ base.

The OQQs represent a substantial improvement in spatial accuracy over previous products used for compilation of tract and farm field boundaries for two reasons—relief displacement and other photographic distortions have been removed, and the OQQs are registered to a geodetic reference system. Because the products show imagery and geodetic reference, they are a very useful product for registering other aerial photo-based products, such as existing soil or wetland maps. The OQQs are also useful for direct photointerpretation and delineation of natural resources, such as forest stands, though their resolution is not as good as aerial photography of like scale.
In general, the form and format of the imagery has been acceptable to field office personnel. The only major deficiency is lack of reference to the Public Land Survey System (PLSS). Almost all records maintained by the local field offices directly or indirectly reference the PLSS. The first task of field office personnel after OQQs arrived was annotation of PLSS section corners locations derived from 1:24,000 USGS Topographic Maps.

Digital orthophotos could be a useful product in local field offices, but it will take sophisticated software and large data storage capacity. In the interim, it is possible to use the analog images to provide quick information products to field office clients by plotting farm field and soils information directly on photocopy reproductions or on mylar overlays at the photocopy scale.

The OQQs can provide part of the basis for better exchange of information such as land ownership and liens with local custodial agencies. However, there are several barriers to overcome in Federal program management strategies before there will be successful integration of Federal and local geographic information systems. Federal agencies need to build a general capacity in their local offices to understand and use geographic data, provide flexibility in selection of hardware and software, and encourage active cooperation of field offices with other local land information system initiatives.

Potential User Survey

A survey of agency personnel currently using some kind of large scale image or map products was conducted to determine if and how they would use the OQQs, and what changes would enhance the products for their use. The respondents represented six local, seven State, and three Federal agencies.

After initial mail and telephone contacts, thirty-eight individuals were selected for in-person interviews. Respondents were given a short presentation about the OQQs, including a demonstration of several media and a brochure describing the products. Then, respondents were asked to complete a questionnaire. The questionnaire included questions about their current spatial data use, questions intended to assess their understanding of technical issues such as spatial accuracy and reference datum, and questions concerning their opinions of the OQQs.

Three factors were correlated with participants who responded favorably to the OQQs: understanding of the geometry of aerial photography, applications demanding a high degree of spatial accuracy across extensive areas, and use of geographic information systems. Participants least inclined to adopt the OQQ were those that had ongoing airphoto acquisition programs tailored to their needs.

Several kinds of enhancements to the products were suggested, including different formats (e.g., quarter township centered), leaf off acquisition, shorter production times, and additional annotation. Almost all participants favored some reference to the public land survey system. Participants generally found the collar information useful and complete.
APPLICATION OF ORTHOPHOTOS IN MULTI-PURPOSE GEOGRAPHIC INFORMATION SYSTEMS IN LOCAL GOVERNMENT

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Use of orthophotos in analog form have been accepted by the map users in several cases in mapping. They have served the purpose as map substitutes in unmapped areas, photo revision of existing maps, land-use planning and natural resource inventories. Most of the applications have tended to be single purpose at medium to small scale, such as in preparation of soil maps. Digital orthophoto technology has also appeared on the horizon.

Orthophotos have several inherent limitations for their use. Consistent image quality is difficult to maintain. Any weakness in the aerial photographic image, geometric data, and the photographic transformation process would impact the quality. In reality, it is impossible to have perfect control between flying conditions, exposure, and correct processing. Other constraints relate to optimum photo scale, resolution, limit on projection magnification, difficulty in correct interpretation problem of small features causing fuzziness of data, accuracy models, raster-structured data limiting query types and geographic analysis, cost of reproduction, and further effort involved in extraction and conversion to topological structure. Digital orthophoto technology holds promise but it must exhibit high level of performance and be acceptable as a cost effective reliable source.

The main characteristic of a geographic information system (GIS) is the development of multi-purpose and multi-user system by design to meet the diverse needs of local government. GIS facilities are no longer limited to a single, stand-alone, turn-key system. Local governments are concerned about a balanced community development, creation and maintenance of sound infrastructure, and safe and secure environment for providing a better quality of life to its citizens. Local governments have to devise strategies for development of specific geographic areas, demand limitation, and planned growth-management. They are responsible to provide many service facilities such as schools, transportation facilities, sewage, water, parks and recreation. Land related applications of some users, in particular, engineers, environmental management, and assessments in urban areas are now requiring high order accuracy of data.

Federal grants to local governments have declined. The greatest impact is on community and regional development shifting the responsibilities back to the State and local governments. Local government programs are under greater financial scrutiny by its citizens, requiring full justification and prioritization of spending. Volume and variation in user demand is continuously increasing. Many disciplines involved in spatial data handling are turning for complex answers to GIS. The GIS have to be flexible and be able to respond to dynamic changes. GIS must also be able to integrate with existing land-related databases and eliminate duplication of efforts.
Data quality reflecting the concept of the positional accuracy, attribute accuracy, reliability, logical consistency, currency, and maintainability of the GIS database is the single most important feature of a meaningful GIS. The GIS has to support policy making, management decisions, and a broad array of applications throughout all areas of local government activities. In the context of multi-purpose and multi-user GIS where demands on data quality are high, orthophoto is not a favorable source material to create a database. Original source of aerial photography is preferable.

1 This presentation was solicited by the National Association of Counties (NACo) as an example of a local government’s perception of the usefulness of orthophoto products. The opinion expressed by Mr. Singh, however, does not reflect, nor is it considered by NACo to represent, its official position on the appropriateness of orthophotography for local government applications.
A STRAWMAN PROPOSAL FOR A
NATIONAL DIGITAL ORTHOPHOTOQUAD PROGRAM

Gale TeSelle
U.S. Soil Conservation Service

Introduction

With the emergence of geographic information systems (GIS) technology, many of the Federal agencies, particularly the land management agencies, need an accurate photo-image map that they can use as a common base to portray resource data which can subsequently be digitized to create geographic databases. Such data as soils, wetlands, farm and field boundaries, land cover, timber types, mineral rights, range site information, hydrologic boundaries and water resource data could be shown on these base maps. State and local government as well as the private sector would also greatly benefit from the availability of a photo-image map to accurately portray administrative, cadastral, and resource data. Federal, State, and local government have, for the most, used enlarged aerial photography and/or other inaccurate base maps which are now inadequate due to the growing need to integrate and share geographic data using computers.

Background

A prototype product has been developed through a cooperative agreement between the Soil Conservation Service (SCS), Agricultural Stabilization and Conservation Service (ASCS), and the U.S. Geological Survey (USGS) which is a 1:12,000-scale orthophoto quarterquad. Dane County, Wisconsin was selected as a pilot project area, and the USGS developed 160 1:12,000-scale orthophoto quarterquads in hard copy format and 36 quads in digital softcopy format. Mylar, photographic paper, and lithographic copies were made available for trial-use-and-evaluation to Federal, State, and local officials. Feedback from the project has been positive and they recommend that such products be made for other counties. They also recommended that digital softcopy be provided so that map scale and sheet formats can be changed to accommodate local needs and that at a minimum the public land survey data be printed on the quads.

The Proposal

General: Establish a national orthophotoquad program for the conterminous U.S. based on aerial photography from the National Aerial Photography Program (NAPP). Produce 1:12,000-scale orthophoto quarterquads for approximately 3/4th of the conterminous U.S. and 1:24,000-scale orthophotoquads for the remainder which may not need the larger scale quarterquads. Reach agreement through Federal, State, and local officials as to which areas would receive 1:12,000-scale quads and which areas 1:24,000 scale.

Develop a 10-year schedule for coverage of each State in conjunction with the NAPP schedule. Create both hard copy and soft copy products. Use the specifications developed as part of the Dane County pilot project as working standards until they are finalized by the participants of this program. The soft copy quads would need to be digitally image matched between quad map sheets.
Cost: Using the figure of 54,000 quads for the conterminous U.S., and an average figure of $2,000 per quad to produce either a 1:24,000-scale quad or 1:12,000-scale quarterquad, the average cost would be $35,000,000 per year. The $2,000 per quad is the current figure being used by the USGS to cover their production costs. Additional experience and improved technical procedures through increased production will no doubt lead to some cost adjustments and refinements.

Funding: The program would be financed by Federal, State, and local governments, 50 percent by Federal, and 50 percent by State and local. Those lands owned by the Federal government would be financed by the Federal agencies.

Financing could and would likely come from a variety of sources which would help defray the cost to any one agency. For example, if eight Federal agencies equally participated, the annual cost to each agency would be approximately $2,000,000. The cost for an average size State would be approximately $3,500,000 once every 10 years, or $350,000 annually.

Management: The program would be managed by the USGS through a steering committee chaired by USGS. If cost share dollars are available from the State and local governments, then the Federal agencies will match their funds and authorize production. If cost share dollars are not available, the Federal dollars will be prioritized and certain States or areas will be completed, and others postponed until the next 10-year cycle.

It is envisioned that the USGS and perhaps the USDA have an in-house capability to produce digital orthophotoquads. However, the largest percentage of digital orthophotoquads would be produced by the private sector through Federal contracts.

Conclusion: The need for such a program seems apparent. However, much discussion and documentation of use and cost/benefit will no doubt be necessary as a next step. The management of the program through cooperative funding and building partnerships between Federal, State, and local governments should make the products and program stronger and more viable than a Federal only program. The use of the private sector mapping and photogrammetry companies to produce the majority of orthophotoquads will further strengthen the program.
ORTHOPHOTO QUARTER QUAD
PROPOSED SPECIFICATIONS

- **IMAGERY**  Black & white made from NAPP CIR
- **FORMAT**   3-3/4 minutes by 3-3/4 minutes
- **SIZE**     24" X 30"
- **SCALE**    1:12,000 (1" = 1,000')
- **PROJECTION** Universal Transverse Mercator (UTM)
- **ACCURACY** Meets National Map Accuracy Standards
  (+ or - 33 feet)
- **DATUM**    New North American Datum 83
- **COLLAR**   Map name
  UTM & State Plane Coordinates
  83 Datum and 27 Datum corners
  Credit note
  Bar scale
  Locator index
  Image overedge
- **DIGITAL**  50 micron resolution
ORTHOPHOTOGRAPHY CAPABILITIES OF THE PRIVATE SECTOR:
AN IMPORTANT CONTRIBUTION TO NATIONAL PROGRAM DEVELOPMENT

Bryan J. Logan
Photo Science, Inc.

Companies from the private sector currently supply up to 90 percent of the unclassified market for ortho-photo mapping. Clients range from engineering firms, mining companies, telecommunications firms, and utility companies in the private sector to a variety of public agencies in municipal, State, and Federal government.

Industry wide, the current orthophoto production capacity of the private sector amounts to 100,000 original orthophoto map sheets per year using analog systems and 15,000 images per year using digital orthophoto workstations. Products take a variety of forms depending on the customer’s requirements: the private sector can generate orthophotos in black-and-white, false color IR, and color at scales ranging from 1:240 (1”=25') up to 1:50,000 (1” = 4166'). In addition, the private sector typically supplies application data overlays to the orthophoto base specifically tailored to individual clients’ requirements.

To keep pace with the latest technology and the demands for increasingly sophisticated mapping products, companies offering orthophoto services have invested millions of dollars in hardware and software development as well as training. Hardware investments include the acquisition of state-of-the-art orthophoto production systems such as those developed and sold by well-known instrument manufacturers. Moreover, in the last few years, some private-sector firms have invested even further to develop or adapt existing scanning systems and imaging workstations to produce digital orthophoto products in both black-and-white and color. This innovation has dramatically increased the potential applications of orthophoto mapping in geographic information systems.

With extensive experience in assisting both private- and public-sector organizations in the development of orthophoto land bases for geographic information systems, companies in this industry have used their market and technical knowledge to recommend creative approaches to the funding of orthophoto projects. By building a consortium of end-users with comparable land-base requirements, these mapping firms have facilitated the pooling of resources enabling all involved to obtain higher quality products more quickly than if they were to attempt to fund them alone.

These private-sector companies extend an invitation to public agencies at Federal, State, and local levels to become involved in such approaches, further enhancing the production of orthophoto land bases, the crucial foundation of all geographic information systems. Well-equipped, technically strong professional firms are confident in asserting their capability to help the public sector achieve its goal of developing sophisticated hard-copy or digital orthophoto mapping programs.
APPENDIX A

FORUM ON ORTHOPHOTOGRAPHY
CO-SPONSORING AGENCIES* AND COOPERATING ORGANIZATIONS

California Department of Emergency Services
Fairfax County, Virginia, Division of Communications
Fresh Water Biological Research Foundation
Insight International
Maryland Water Resources Administration
• National Association of Counties
• National Governors’ Association
Photo Science, Inc.
U.S. Agricultural Stabilization and Conservation Service
U.S. Bureau of Land Management
U.S. Fish and Wildlife Service
U.S. Forest Service
• U.S. Geological Survey
U.S. Naval Civil Engineering Laboratory
• U.S. Soil Conservation Service
University of Wisconsin
APPENDIX B

FORUM ON ORTHOPHOTOGRAPHY

NASA Goddard Space Flight Center
Greenbelt, Maryland
May 15, 1990

REGISTRATION SUMMARY

FEDERAL GOVERNMENT

CONGRESSIONAL OFFICES

Library of Congress

EXECUTIVE OFFICE OF THE PRESIDENT

Central Intelligence Agency

INDEPENDENT AGENCIES

Environmental Protection Agency
Federal Energy Regulatory Commission
General Services Administration
National Archives and Records Administration
National Capital Planning Commission
Nuclear Regulatory Commission

OTHER FEDERAL ORGANIZATIONS

Tennessee Valley Authority

DEPARTMENTS

Department of Agriculture

Agricultural Research Service
Agriculture Stabilization and Conservation Service
Forest Service
National Agricultural Statistics Service
Soil Conservation Service

Department of Commerce

Bureau of the Census
National Ocean Service
Department of Defense

Defense Intelligence Agency
Defense Mapping Agency
U.S. Army Engineer Topographic Laboratories

Department of Energy

Oak Ridge National Laboratory
Pacific Northwest Laboratory

Department of Health and Human Services

National Center for Health Statistics

Department of Housing and Urban Development

Office of Environment and Energy

Department of the Interior

Bureau of Indian Affairs
Bureau of Land Management
Bureau of Mines
Fish and Wildlife Service
Geological Survey
Minerals Management Service

Department of Labor

Mine Safety and Health Administration

Department of State

Bureau of Intelligence and Research

Department of Transportation

Federal Highway Administration
STATE AND LOCAL GOVERNMENT

California

Office of Emergency Services

Delaware

Department of Natural Resources and Environmental Control
New Castle County Department of Planning
New Castle County Water Resources Agency

Maryland

Anne Arundel County Planning and Zoning
Carroll County Department of Management and Budget
Charles County Department of Planning
Department of Natural Resources
Geological Survey
Harford County
Montgomery County Office of Planning Policies
National Capital Park and Planning Commission
Office of Planning
State Highway Administration
Water Resources Administration

Michigan

Department of Natural Resources

Minnesota

Office of State Planning

Pennsylvania

Pennsylvania Geological Survey

South Carolina

Land Resources Commission

Vermont

Division of Property Valuation and Review

Virginia

Fairfax County Division of Communications

West Virginia

Geological and Economic Survey
NON-FEDERAL ORGANIZATIONS

National/Professional Organizations

American Congress on Surveying and Mapping
MAPPS

Private Industry

Analytical Surveys, Inc.
Carrington Cass Technologies, Inc.
Greenhorne and O'Mara, Inc.
Insight International
Intergraph Corporation
International Imaging Systems
John G. Reutter Associates
MARC, Inc.
Photo Science, Inc.
SPOT Image Corporation

Academic Institutions

Frostburg State University
Purdue University
Salisbury State University
University of Massachusetts
University of Wisconsin-Madison

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This survey was distributed in July 1990 to Forum participants and to a number of others representing the public and private sectors. Its purpose is to assist in the evaluation of the U.S. Soil Conservation Service proposal for a national digital orthophotoquad program. Responses from organizations will be analyzed by the U.S. Geological Survey to determine the requirements for, and feasibility of, implementing the proposed national program.

HIGHER RESOLUTION ORTHOPHOTO PRODUCTS SURVEY

USER PROFILE

1. Individual respondent:

   Name: ___________________________________
   Title: ___________________________________
   Organization: (1) _________________________
                (2) _________________________
                (3) _________________________
   Address: ___________________________________
   City: ___________________________________
   State: __ Zipcode: __________ Telephone: (___)-____-_____
          FTS - ___-

2. Organization: __ federal __ state __ county __ city __ private __ other (specify) ____________________________

3. What is your organization's primary activity? ___________________________________
   ___________________________________
   ___________________________________

4. For what type(s) of area are you responsible? (Check all that apply)

   __ Urban __ Rural __ Rangelands __ Coastal
   __ Flood prone __ Forest __ Agricultural __ Wetlands
   __ Other (specify) ____________________________

5. What is your geographic area of responsibility?

   __ nationwide __ statewide __ county __ city __ regional
   __ coastal zone __ other (specify) ____________________________

6. For how much land area is your organization responsible?

   ______ square miles; ______ 7.5-minute quadrangles; or
   ______ ______ (alternate unit of measure).
CURRENT PRODUCT USAGE/APPLICATIONS ASSESSMENT

[Note: several definitions are provided in the Glossary on the last page for your use in the completion of this Survey.]

7. Do your applications require spatial information such as, maps, charts, aerial photographs, or geographic coordinate information?
   __ yes  __ no

   If yes, go to item 10

8. If you do not use maps or aerial photoimage products, please indicate the reason(s):
   __ use not appropriate for organization's application
   __ not available in scale, format, coverage, or resolution required
   __ unaware such products existed
   __ unaware products were available for my area
   __ did not know how or where to obtain the products
   __ cannot budget for their purchase or production
   __ lack expertise in use of products
   __ other (specify)__________________________________________

9. Can you anticipate your organization's use of maps or aerial photographic image products in the conduct of its mission in the next 2-10 years?
   __ yes  __ no

   If no, go to item 39.

10. Do you consider line and/or image maps to be essential to the conduct of your mission activities?
    __ yes  __ no

11. My organization
    __ uses line maps:
        scale = 1:____ produced by:____________________________________
        scale = 1:____ produced by:____________________________________
        scale = 1:____ produced by:____________________________________
    __ does not use line maps
12. Please specify which type of aerial photography or satellite imagery your organization uses for its program activities:
- photomosaics  
- contact prints  
- rectified prints  
- orthophotos  
- digital:  
- aircraft  
- satellite  
- radar  
- other (specify)  
- does not use aerial or space photographic imagery

13. If your organization currently uses orthophotography, of what scales are your products? 1:________; 1:________.
- does not use orthophotography  
  Go to item 19.

14. Who produces your orthophotos?
- USGS  
- USFS  
- BLM  
- other Federal  
- State agency (specify)  
- local agency or department (specify)  
- quasi-government agency (i.e. planning commission)  
- private contractor  
- in-house

15. For what purposes do you currently use orthophotography?
- management  
- project design  
- evaluation and analysis  
- field work  
- data gathering  
- project planning  
- GIS application  
- education  
- other (specify)

16. How do you use orthophoto products?
- as a supplement to line-map products  
- in lieu of line-map products

17. If you use USGS 1:24,000-scale orthophotos, do you modify the product prior to use?
- do not modify  
- enlarge from 1:24,000-scale to 1:________
- reduce from 1:24,000-scale to 1:________
- mask or screen data  
- change format from quadrangle to  
- change extent from 7.5 x 7.5 minute to  
- scan to produce digital image  
- other (specify)
18. Do you add information to the image? If yes, what types?
   __ do not add information
   _ US Public Land Survey System __ names __ control
   _ boundaries __ roads/trails __ drainage __ vegetation
   _ contours/spot elevations __ wetlands
   _ other (specify) ________________________

19. If you do not use USGS 1:24,000-scale orthophotos, please indicate the reason(s):
   _ lack sufficient resolution
   _ are out-of-date
   _ not available in scale, format, coverage, or resolution required
   _ prefer color
   _ don't need higher resolution
   _ unaware such products existed
   _ unaware products were available for my area
   _ did not know how or where to obtain the products
   _ cannot budget for their purchase or production
   _ lack expertise in use of products
   _ other (specify) ________________________
   _ no current requirement for orthophotography  Go to item 23.

20. Would an image scale of 1:12,000 be adequate for your intended application?
    __ yes  __ no  If no, explain________________________________________

21. Do you prefer aerial photography acquired when foliage is:
    __ on the trees  __ off the trees

22. What frequency of update do you require for orthophoto products?
    __ annually  __ 2-3 years  __ 4-5 years
    __ 6-10 years __ 11-20 years  __ other (specify)____________________
23. If you are not using orthophotos, would you anticipate their use in 2-10 years?
   __ yes  __ no

   If no, go to item 39.

FUTURE PRODUCT NEEDS

24. Can you foresee additional uses by your organization for orthophotos if they were of a higher resolution? __ yes __ no

25. If yes, what would they be?

26. Do you use digital imagery to help conduct your program activities? __ yes __ no

27. Would you be interested in using a digital orthophotographic product in your application? __ yes __ no

28. If you are not using digital imagery, do you anticipate its use in 2-10 years? __ yes __ no

29. If you anticipate using orthophotographic products, would you prefer:
   __ hard-copy  __ soft-copy (digital)  __ both

30. For a conventional hard-copy orthophotographic product, would you prefer:

   Scale and Spatial Extent
   __ a 1:24,000-scale (1" = 2,000'), 7.5-minute x 7.5-minute product
   __ a 1:12,000-scale (1" = 1,000'), 3.75-minute x 3.75-minute product
   __ other(specify)______________________________

   Image
   __ a black and white product
   __ a color infra-red product

D-5
Datum
  _ NAD27 _ NAD83
Image Product
  continuous tone ___ half-tone ___ embedded data
Media
  prints reproducible
Other Parameters ________________________________

31. For a digital, soft-copy orthophotographic product, would you prefer:
  Scale and Spatial Extent
    ___ a 1:24,000-scale (1" = 2,000') 7.5-minute product equivalent
    ___ a 1:12,000-scale (1" = 1,000') 3.75-minute product equivalent
    ___ other (specify) ________________________________
Image
    ___ a black and white product
    ___ a color infra-red product
Image Resolution (9" x 9" black and white image)
    ___ 25 microns (55 megabytes storage requirement)
    ___ 50 microns (13 megabytes storage requirement)
    ___ 100 microns (4 megabytes storage requirement)
    ___ other (specify) ________________________________
Distribution Media
    ___ 9-track tape ___ CD-ROM ___ digital audio tape
    ___ other (specify) ________________________________
Datum
  _ NAD27 _ NAD83
Other Parameters ________________________________

FUNDING CONSIDERATIONS

32. Do you believe your organization would be willing to participate in a national orthophotoquad program?  ___ yes  ___ no

33. Would your organization be willing to contribute funding on an annual basis?
    ___ yes  ___ no; on a year-of-need only basis?  ___ yes  ___ no
34. If sufficient funding is not secured for a national program as proposed by the Soil Conservation Service, would your organization be able to cost-share (50/50) for required products in your areas of need?  
   _ yes _ no

35. If you are a current user of orthophotographic products, what are your estimated expenditures for this type of product this year? $___________

36. Do you believe the availability of higher resolution orthophoto products would result in a cost savings to your organization?  _ yes _ no

37. Do you believe that your positional accuracy requirements are sufficient to justify a higher resolution orthophotographic product?  
   _ yes _ no

38. Would you be willing to be interviewed to discuss your needs further?  
   _ yes _ no

39. Thank you for your time in responding to this survey. An analysis of the requirements for higher-resolution orthophoto products will be prepared based on the results of this survey.

Please return the completed survey by August 20, 1990 to:

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   345 Middlefield Road  
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GLOSSARY

DIGITAL ORTHOPHOTOGRAPHS: a computer-compatible data set with all the metric properties of an orthophOTO, which can be manipulated, overlayed, displayed, plotted, and archived using digital image processing and geographic information systems.

HARD-COPY: refers to a graphic product, usually produced in connection with a computer or analog system, that is readable without the use of specialized equipment. Examples are maps or imagery printed on paper or mylar.

IMAGE MAPS: photographic characterizations of the features on the surface of the earth presented in the form of a map. Images may be derived from cameras, scanners, radar, or other type of sensor.

LINE MAPS: graphics characterizing the natural and man-made features on or below the surface of the earth through the use of symbols. Examples are topographic, land-use/land cover, and planimetric maps.

ORTHOPHOTOGRAPHS: a photographic reproduction prepared from an aerial photograph in which the displacement of images due to camera tilt and terrain relief have been removed. It has the same metric properties as a map and also has a uniform scale.

SCALE: numerical representation of the relationship between a distance on a map and that corresponding distance on the earth. For example, a scale of 1:24,000 means 1 inch on the map represents 24,000 inches (or 2,000 feet) on the ground.

SOFT-COPY: refers to computer output on a medium, such as magnetic tape, disk, or diskette, that cannot be read without specialized equipment. Digital imagery is an example.

RESOLUTION: is the ability of an imaging system to display a sharply defined feature.

SPATIAL DATA: are geographically referenced features that are described by geographic positions and attributes in an analog and/or computer readable (digital) form.

SPATIAL EXTENT: refers to the size of a map expressed in terms of the north-south and east-west geographic dimensions of the map. For instance, the spatial extent of a typical USGS 1:24,000-scale map is 7.5-minutes of latitude (north-south) by 7.5-minutes of longitude (east-west).