Building a Production System to Support the National Digital Orthophoto Program: An Integration Challenge

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ABSTRACT

The goal of the National Digital Orthophoto Program is to produce digital orthophoto coverage of the conterminous United States by the year 2001. The lack of budgetary and production resources necessary to complete this task requires the creative pooling of resources and performing the majority of the production work through contracts with private industry. The sudden demand for digital orthophotos also forced the U.S. Geological Survey to accelerate the development of its production system. The development task was particularly complex because of the integration issues involved with satisfying multiagency requirements, the legacy of data from analog production methods, and quality assurance issues associated with data produced by several contractors. The development of a production system without accepted standards prolonged the development cycle. The development was further complicated by a change to a distributed database strategy.

INTRODUCTION

The goal of the National Digital Orthophoto Program (NDOP) is to produce digital orthophoto coverage of the conterminous United States by the year 2001. A steering committee composed of Federal agencies and State organizations provides oversight and technical leadership for the program. The U.S. Geological Survey (USGS) is responsible for administering the program. The production strategy is to accomplish the majority of the work by contracting to firms in the private sector. This contracting strategy introduces a need for quality control tools within the production system. The digital orthophoto production system developed by the USGS in support of the digital orthophoto program evolved from a feasibility study and a prototype system. At the time, commercial software was not available in the United States to produce digital orthophotos.

BACKGROUND

The USGS, National Mapping Division, began producing analog orthophotos in 1964 using custom-built orthophoto equipment developed within the agency. For the next 25 years, the agency produced analog orthophotos that often provided users with the only accurate base map in areas where the 7.5-minute topographic maps did not exist. During this period, the USGS also used three generations of commercially manufactured orthophoto equipment.

In the late 1970's, the agency began its digital data programs that included digital elevation data as well as digital line graph data. The digital elevation data were collected, resampled, and formatted as a by-product of the analog orthophoto production process. In 1985, the National Mapping Division began its development of the current digital orthophoto system through a feasibility study made at its Western Mapping Center that demonstrated the generation of digital orthophotos from scanned diapositives using a minicomputer. Sample digital orthophoto products were created over the next several years and although they were received with much interest, there were no demands for a production implementation of the prototype system. A pilot project in Dane County, Wisconsin, which was presented at the first National Digital Orthophoto Forum in 1990, provided the impetus for nationwide coverage of digital orthophotography.

During the development period, the agency produced analog orthophotos using the Wild OR-1 orthophoto system*. The general lack of standards for analog components of the production process extended the development time for the system and ultimately required a system modification as standards were redefined. Furthermore, the transition period from an analog orthophoto generation process to a digital process created a legacy of digital and nondigital components, which added to the integration problem. Finally, new requirements and technology changes introduced new integration issues. This paper describes the evolution of the current production system and its current capabilities.

PRODUCTION STRATEGY

The demand for digital orthophotos increased due to the maturity of GIS technology, the general lack of current base cartographic data, and the dramatic drop in computer hardware costs. This sudden demand for digital orthophoto data could not be met with existing resources and budget levels. Pooling of government resources and relying on private industry were practical solutions to the budget limitations and the limited production capacity.

SYSTEM AND DESIGN CONSTRAINTS

Although the USGS had long abandoned any in-house photogrammetric hardware development, the agency continued software development to perform system integration tasks. For the digital orthophoto development, the USGS expanded its prototype software into a digital production system because commercial software was not available. However, the system design was for a modest amount of production work because the production strategy was to accomplish the majority of the work by contracting to firms in the private sector.

The basic inputs to the present system are (1) diapositives generated from available photography acquired from the National Aerial Photography Program (NAPP), (2) camera calibration data, (3) existing photoidentified control from previous mapping projects, (4) aerotriangulation data in different formats, (5) existing digital elevation model (DEM) data from the National Digital Cartographic Database, and (6) topographic maps (fig. 1, box A).

The National Aerial Photography Program is a cooperative program with State and Federal agencies to acquire color-infrared or black-and-white aerial photography over the conterminous United States on a cyclic basis. Photography from this program is the primary source imagery for the digital orthophoto program and diapositives are generated from the original aerial film. In this scenario, the aerial photography has already been inspected using strict standards. However, there are many instances where existing photography is not suitable for the requirements of the orthophoto user. In these situations, the aerial photography is acquired by the mapping contractor as part of the digital orthophoto contract. In this second scenario, inspection of the newly acquired photography is required before production of the digital orthophoto begins. The two scenarios presents two dataflow paths through the production process. In-house production scanning also presented two dataflow paths because diapositive scanning was performed on two scanners made by different manufacturers, which required slightly different data handling.

Since the USGS has the responsibility for camera calibration in the United States, the necessary camera calibration information is readily available for in-house production purposes. However, the current USGS camera calibration process does not provide the calibration results in digital form to the contractors or to the general public. In general, users are required to manually enter camera calibration data into their orthophoto rectification systems.

Where feasible, photoidentified control points from previous mapping projects are used to reduce the cost for additional field control. The use of these data constrains this portion of the production system to be analog because these data are obtained entirely from analog techniques.

When available, digital elevation data from the National Digital Cartographic Database were extracted and used in the orthophoto generation. However if digital elevation data were not available, they were generated by photogrammetric methods or derived from digitized hypsographic data. This represented two additional dataflow paths.

ADDITIONAL DESIGN REQUIREMENTS

In addition to producing the standard 3.75- × 3.75-minute digital orthophoto quadrangles (DOQ's), mosaicking of DOQ's into the traditional 7.5- × 7.5-minute quadrangle format and limited hardcopy image output was necessary for specific needs. Data delivery requirements include archiving in a format for easy use in various GIS systems while providing sufficient metadata for data management purposes. These requirements also include using a compression algorithm that is in the public domain and available on various computer platforms, and distributing the data on various media.

STANDARDS DEVELOPMENT

Since digital orthophoto data are to be generated by other agencies and private contractors, there is an obvious need for DOQ standards (fig. 1, box B and C). Currently two standards are being developed in the United States. The USGS has been working with participants of the National Digital Orthophoto Program to develop standards for the digital orthophoto (U.S. Geological Survey, 1995). Meanwhile, each Federal agency also participates on the Federal Geographic Data Committee to develop digital orthophoto standards for the National Spatial Data Infrastructure (Federal Geographic Data Committee, 1995). Unfortunately, an accepted national standard was not available before system development began. Furthermore, the long review process and the iterative changes to the draft standard complicated the system development effort and prolonged the development period.

Digital orthophoto production by other agencies and contractors also adds a functional requirement that the

digital production system validate data deliverables from all data producers to ensure that the product meets standards. These data include field control, airborne GPS, aerotriangulation data, DEM's, digital orthoimagery, digital orthophoto metadata, orthophoto mosaics, and hardcopy (fig. 1, box D). System design and integration were more complex because there were no standards for many of these data elements.

DATABASE CONSIDERATIONS

In addition to several iterations of standards changes, the database approach for the National Digital Orthophoto Program also changed. This necessitated reprocessing of data in the archive. The USGS changed from a centralized archive to a decentralized database for all its data holdings. Operational databases (ODB) were established within regional production centers for their respective data responsibilities. Furthermore, a sales database (SDB) was implemented for distribution of data to the general public (fig. 1, box E). The transition from a centralized model to a decentralized model altered the dataflows and further affected the system development activity.

CONCLUSIONS

Budget constraints imposed additional complexities to the design task because each hardware component was procured on separate contracts over a period of several years and system integration was performed entirely by in-house personnel. The sudden demand for a production system, the general lack of standards, constantly changing requirements, a mixture of analog and digital inputs, a multivendor hardware environment, and budgetary constraints were all factors in making the development of the digital production system an integration challenge.

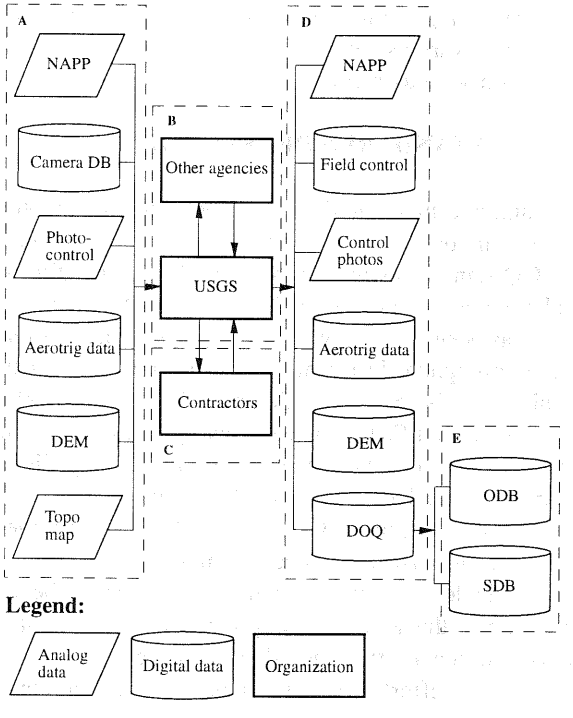

Figure 1. Digital orthophoto production system dataflow.

REFERENCES

U.S. Geological Survey, 1995, Draft Standards for Digital Orthophotos: National Mapping Program Technical Instruction.

Federal Geographic Data Committee, 1995, Draft Standards for Digital Orthoimagery.

* Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.