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STATUS MAPPING:
A COMPUTER-ASSISTED APPROACH

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ABSTRACT

As part of its normal topographic mapping activities, the National Mapping Division (NMD) of the U.S. Geological Survey (USGS) periodically compiles, prints and publishes status maps and indexes. These publications graphically portray not only the progress of NMD's topographic mapping activities but also the availability of NMD's various digital and graphic map products. The methods used by NMD to compile and print the mapping status graphics now are largely manual and, therefore, very labor- and time- intensive. This results in long leadtimes to compile and publish the graphics. The long leadtimes in turn cause long and irregular intervals between graphic updatings and they also create lapses in the chronological currency of the compiled status data. This process ultimately culminates in the information portrayed being almost unusably out-of-date even before it is printed and distributed to the information users; i.e., the USGS map product customers and the NMD program planners and managers. The author proposes a series of software and technique development steps that are recommended as one possible solution to these companion problems of irregular updating and lapses of informational currency. These steps are designed to move NMD from the current minimally computer-assisted and predominantly manual mode of map status graphic preparation activities to a more sophisticated and more highly automated degree of computer-assisted status mapping operation. This procedure, if followed, will enable NMD to provide its product users with more current

mapping status information; to update that information more frequently and regularly; and to do so through expenditure of less time and effort than are required by the present mode of operation.

INTRODUCTION

The National Mapping Division (NMD) of the U.S. Geological Survey (USGS) periodically prepares and prints mapping status materials that graphically represent the progress made by NMD in its efforts to compile, at appropriate scale, and update the topographic mapping of the United States. These materials range from simple graphics showing only those large areas that have, or have not, been mapped at a given scale to the very complex graphics that indicate mapping progress status and data availability on the basis of individual 7 1/2-minute quadrangle maps. Heretofore, these graphics have been created entirely through use of labor-intensive manual techniques. The baseline information was hand-drawn or hand-engraved with a coordinatograph and straightedge ruling devices, and the textual information was added by means of hand-lettering or manual stickup of machine-generated phototype. The digitally driven automated drafting machines (Calcomp, Gerber, etc.) have recently begun to be used as replacements for the manual coordinatographs and straightedges, and the alphanumeric-character-type status code symbology has been largely replaced by area-fill pattern symbology that is generated by photomechanical lithographic techniques.[1] The entire procedure, however, is still largely manual; and the status mapping graphics are, therefore, still costly to create. Also, this process often requires an unacceptably long leadtime to collect the status information and then compile and print the status graphic. Two currently developing NMD

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[1] Any use of trade names and trademarks in this publication is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

activities have begun to further negatively impact the currency of the status information and the leadtimes required to print the graphics. The first of these activities originated in the NMD decision to generate a line of digital map products that supplements the standard line of graphic products. This activity has significantly increased the number of individual map products that can be made available for any single 7 1/2-minute quadrangle; and this has, in turn, significantly increased the complexity of the status code symbology required. The second activity is the consequence of an inevitable tendency to authorize smaller areas of primary and revision mapping as NMD comes increasingly closer to completion of its primary 1:24,000-scale 7 1/2-minute map series coverage of the U.S., and as more of the mapping activity consequently shifts from a primary-mapping orientation to a map-revision mode of activity. This causes the previously small number of large and rectangular mapping project areas to be supplanted by a larger number of smaller areas with more complex boundaries, and this also increases the amount of manual labor and information checking (verification) required to compile each mapping status graphic.

The intrinsic value of any mapping status document lies primarily in the chronological currency of the information that it carries, and secondarily in its ability to convey a maximum amount of easily readable information at minimal cost. Therefore, any improvement in these two values clearly represents a net worth gain for the users of these graphics; i.e., the NMD program managers and the USGS map product customers. Advances in hardware technology over the past 6 years have greatly increased the flexibility and capabilities of the electronic equipment required for computer-assisted composition, editing and printing of the status mapping type of graphic; and the USGS NMD has recently acquired, and made operational, equipment suitable for this type of application. The main body of this document sets forth a sequence of steps the author proposes as a possible series of developmental procedures designed to exploit this new technology and thereby gradually move the compilation of topographic mapping status graphics away from the present minimally computer-assisted manual mode of operation and toward the highly automated mode of graphic generation that will be required to create future status graphics of satisfactory cost and informational currency. The steps described herein refer to several types of electronic digital cartographic equipment by specific name. This is done only because these are the equipment presently owned by and in possession of the NMD. Obviously, a similiar set of steps could be devised for any similiar set of hardware of equal or greater capabilities.

RECOMMENDED PROCEDURE

Step 1: Preliminary Design

This step comprises the efforts involved in selection of the format and content of each status graphic base to be developed. This would be the selection and(or) design of the geographic projection, scale, size, grid tick and(or) gridline size and spacing, number and character of status code symbologies, and content and location of credit legend and other textual information that is to appear on the final status graphic. As with most other design tasks of this type, it is recommended that the final graphic design effort be preceded by a Requirements Analysis Study in order to determine: (1) what information the ultimate users need; (2) what levels of informational currency are required; (3) the users applications for the graphic; and (4) the most usable (readable) form for presentation of the status information to the ultimate users.

Step 2: Acquisition of the Base Source Graphic

Once the content and format of the base are known, the master base source graphic must be manually constructed or otherwise acquired. Ideally, this would be in the form of high-quality photographic copy that is printed on scale-stable material. If available, a scale-stable copy of the most recent status graphic may be used for a start. However, the Requirements Analysis Study may surface some desirable changes in content that would dictate modification of the source graphic; either at this step, or during Step 3.

Step 3: Generation of Digital Base Master File (DBMF)

This is the process of scanning the base source graphic with the NMD Scitex RESPONSE 250 system, or similiar instrumentation of equal capability; and of archiving the information in digital magnetic raster data form on tape or disk. The data can then be recalled from magnetic storage as needed for purposes of compositing in register and merging it with the revising information needed for periodic updating of the final status graphic each time it is reprinted. This operation will require careful planning and selection of the scale, sampling spot size and resolution used for the scanning; as well as some editing of the digital raster data set using the interactive operator commands and other functional tools incorporated in the Scitex equipment. These same interactive tools can also be used for selective modification of content and improvement of the aesthetic quality of the information on the base source graphic during this operational step, if appropriate. One other important function to be accomplished during this step is interactive query of the Scitex for the machine coordinates of a minimum of 4 (the 4 corner ticks), preferably 9 (3 x 3), 16 (4 x 4), or 25 (5 x 5) uniformly distributed grid intersections that are to be used for subsequent registration, scaling and fitting of the revision information that is to be merged with the master file to update the status graphic as needed for periodic reprinting.

Step 4: Compilation of Current Status Code Areas

Again, a copy of the most recent status graphic, if available, will suffice to begin this task. A scale-stable copy is preferable; but a paper copy can be used, provided that the informational content and method of graphic presentation of the spatial data are appropriate and usable. In either instance, the copy to be used would be scanned on the Scitex; color-separated while scanning; fit to the Digital Base Master File (DBMF); then composited, in precise registery, and merged with the DBMF. The merged data set can then be archived, on tape or disk, for future recall as the Current Status Graphic File (CSGF). The laser printer of the Scitex RESPONSE 250 can then be utilized to print photographic copy of the CSGF.

Step 5: Manual Update of Status Graphic

Copies of the CSGF, photomechanically transferred (contact-printed) to scribecoat, would be delivered to the Mapping Center (MC) or other personnel assigned responsibility for the task of making the modifications of status code window boundaries required to bring the CSGF information to a satisfactory level of chronological currency. If the CSGF cannot be generated because of either lack or unsuitability of an original source graphic, photographic copy of the DBMF will have to be substituted for the CSGF for the manual updating process. An alternate approach to manual updating of the DBMF would entail making Calcomp or Gerber vector plots of the status code window boundaries (sans cross-hachure fill), as is done at the present time.

Step 6: Computer-Assisted CSGF Update

The manually updated CSGF graphics (or digitally driven drafting machine photo/pen plots) can be scanned on the Scitex equipment, and the data interactively edited as needed to achieve adequate informational content and quality. The updating information can be interactively fit to the archived CSGF, composited in precise register with it, and merged to form a new CSGF (CSGF2). CSGF2 can then be interactively edited as required to accommodate the updating changes. Line screen fill or other status code pattern symbology can be interactively assigned to each status code window as appropriate, and the archival CSGF2 then generated and stored. The archival CSGF2 can be used to print the photographic color-separates needed for lithographic or other hard-copy printing of the status graphic until such time as CSGF2 is updated to generate and archive CSGF3.

These first six steps constitute Phase I, and they would result in a technical procedure that is moderately computer-assisted, but that is still excessively labor-intensive. The next sequence of steps, Phase II, are, therefore, proposed to further reduce the amount of manual involvement in the process. These follow-on steps could actually proceed in parallel with the first six, or even supplant them, provided that sufficient software and other programing resources were made available to the development tasks described.

Step 7: Develop Status-Code-Window Digital Encoding Techniques

This step comprises the efforts required to develop the software and operational techniques needed to enable MC personnel (or others) to encode the status-code-window boundary information digitally, rather than by scribing or other manual drafting technique. Any sort of manual digitizing table or tablet (Altek, Summagraphic, etc.) could be used for this purpose, as could any of the design stations of NMD's Intergraph Corporation computer-assisted design and drafting systems. At its simplest, this effort could comprise the software techniques required to produce plottapes for the NMD Calcomp, Kongsberg, or Gerber automated drafting equipments. The drafting hardware would subsequently be employed to produce graphic copy suitable for digital raster scanning and composition as described a la Step 6. Ultimately, however, the data should be encoded for input into those portions of the Geographic Information Retrieval and Analysis System (GIRAS) software that assemble polygons around an internal area node and then check for polygon closure and attributal integrity.

Step 8: Develop Scitex Coordinate Entry Techniques

This step comprises the efforts required to develop the techniques to read manually acquired coordinate data from Step 7 into the Scitex and subsequently draw the window outlines and assign selected pattern codes with the minimal amount of interactive Scitex operator intervention possible. Alternatively, development (with selected components of GIRAS) could proceed with incorporation of those GIRAS components that convert polygon boundary (line vector) data to grid cell (raster area) form and format it for input to the Scitex equipment. The latter approach is most highly recommended because: (1) it represents a higher degree of automation and sophistication of the computer assistance; and (2) the program and technique development tasks are seen to be less complex, and also to require significantly less man- and (or) machine-hour resources for both the developmental and the operational activities. In either case, however, the Scitex equipment (or its equal) would still be required for interactive fitting, compositing, merging, editing, etc., as described in Step 6.

At the conclusion of Step 8, the process will have attained a higher degree of computer-assistance sophistication than at the conclusion of Step 6. However, the procedure will still be excessively labor-intensive and hardware-dependent. The following steps, Phase III, are proposed as one means of further minimizing these labor and hardware dependencies. Unfortunately, these steps are also the ones that require the most developmental efforts and resources. As with Steps 7 & 8, some of this effort can occur in parallel with Steps 1-6, (Phase I) provided that the requisite developmental resources are made available. Indeed, it is recommended that the next efforts described be initiated at the earliest possible date because they are seen as being complex, with respect to NMD long-range policy as well as technically, and they are also seen as requiring a substantial amount of developmental time and talent. These two factors will, of necessity, result in long leadtimes between initiation of the efforts and implementation of operational procedures. The lengths of these leadtimes will, of course, be inversely proportional to the amount of developmental time and talent committed to the project.

Step 9: Analysis of Requirements for Automated Status Map Graphics

This is the process of determining the forms, content, and uses of the status graphics to be automated. If a formal Requirements Analysis was not performed a la FIPS PUB 38 as part of Step 1, it must be performed as part of this step.[1] Ideally, the analysis should be executed as part of Step 1; and the analysis should also be sufficiently thorough to include the data needed to proceed logically to Step 10 and beyond.

Step 10: Develop Software, Procedures, and Data Bases for Automated Entry and Recall of Mapping Status Information

At the present time, most of the available graphic mapping status information exists in T-70 or one of the other subsets of the Topographic Resources and Cost Evaluation (TRACE) system. However, TRACE is now in the process of being replaced by another system that is as yet undefined; and the digital mapping status information is held in other inventory systems that are separate and apart from TRACE, and to some degree from each other. The functions of Step 10 will be: (1) to identify the sources of mapping status information required for the graphic automation project; (2) to either acquire computerized access to these sources or collect the needed information in a common centralized data base; and (3) to develop the software and techniques required to access the information for interactive entry and update via computer terminal and recall the information in form and format suitable for direct entry into a number of laser and CRT raster electronic display and(or) printing devices. One of these output devices will, of course, be the laser printer of the Scitex RESPONSE 250 equipment.

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[1] Federal Information Processing System Publication 38, U.S. Department of Commerce, National Bureau of Standards.

Step 11: Develop Software, Lookup Tables, etc., Required to Translate Individual 7 1/2-Minute Quadrangle Latitude/Longitude References into 7 1/2-Minute Pattern Windows

This (and subsequent steps) represent development of the software and technique components that exist in the operational area between recall of status information from the data base of Step 10 and the printing of the status graphic information on CRT display devices, laser or ink jet printers, etc. These (Step 11) software components must enable the user to query with, or input to the data base, map position indexing information in the form of Latitude and Longitude; and have the data base return or output Cartesian (x,y) coordinates that are suitable for use with the target output display device of the user. The Scitex machine coordinates system is one possible candidate for such application. If the present equirectangular status graphic projections are retained (a highly recommended suggestion), then the cross-indexing between Lat-Long and Cartesian, and the subsequent computer processing of the 7 1/2-minute quadrangle pattern windows is much less complex, is less prone to manual data entry errors, and requires less time and effort to process than if one of the conical or spherical projections were to be used.

Step 12: Develop Software and Techniques to Input, into the Scitex, Machine Addresses from Step 11, Plus Machine-Dependent Pattern Codes

A number of graphic patterns can be archived in the Pattern Library of the Scitex RESPONSE 250. These patterns can be called up by the system operator and added, either singly or repetitively, to a raster data file as needed to interactively create any overall pattern, or combination of patterns, desired. These pattern windows are positioned by operator commands that specify the starting machine coordinates of each window, its size, its angular orientation, and the name of the pattern that is to fill each window. Step 12 comprises the efforts required to develop the software and techniques: (1) to output, from the mapping status information data base, these operator-input parameters for each 7 1/2-minute quadrangle; and (2) to input these parameters, via magnetic tape, directly into the Scitex equipment with a minimum of Scitex system operator interactive involvement.

Step 13: Development of Machine-Independent Raster Window Patterns

Each of the window patterns used for Step 12 must be hand-drawn, either electronically or mechanically, and then scanned or otherwise stored in the Scitex Pattern Library, along with its name and related recalling information. These pattern windows are thus totally hardware dependent. Step 13 comprises the efforts required to encode the status code patterns in a machine-independent pattern library that is separate and apart from that of the Scitex; and to encode the patterns in a general-purpose non proprietary run-length, perhaps density- or color-coded, raster format that is suitable to a more general (less specialized) class of raster CRT display and laser printing devices. This step includes the development of digitally encoded machine-independent raster pattern matrices (the 7 1/2-minute pattern windows), along with the data base query and file assembly software required to generate a general-purpose color- and (or) density-coded run-length raster data set that can be formatted for input into the NMD Scitex, Comtal, Tektronix, etc., spatially related graphic display devices. These data should be designed and constructed in such manner as to be suitable for both display-only (customer browse and inquiry), and modify (NMD personnel edit and update); as well as for the primary application i.e., providing a means of lithographically printing updated mapping status graphics. The data should also be formatted and archived in such a manner that the graphics files can be readily downloaded into micro-based information display systems used by NCIC Customer Services and MC Plans and Program Management personnel.

Step 14: Formatting For Direct Input to Printing

This step is perhaps logically part, or at least a continuation, of Step 13. However, its successful accomplishment represents the culmination of the total effort and the achievement of the primary goal embodied in the total substance of the 14 steps herein described; i.e., to attain a reasonable and useful degree of sophistication in automation of NMD computer-assisted mapping status graphic preparation activities and operations. Step 14 comprises the design and writing of the software interface module required to read in, as input, the general-purpose machine-independent data sets created by the software of Step 13 and to reformat the data sets and write them to magnetic tape in a form that can be read directly into the Scitex RESPONSE 250 and input directly to the Scitex laser printer with a minimum of Scitex system operator involvement. If this developmental effort proceeds as recommended and as envisioned, a new status graphic raster data set (CSGFn) would ultimately be computer-generated externally (to the Scitex) whenever an updated graphic is required, rather than by merely "updating" an old hardware-dependent Scitex system file as described in Step 6. Therefore, little or no interactive fitting, compositing, editing, etc., should be required; and Scitex (or other) system operator involvement should be limited to job setup and management only at this stage, in which case the ultimate goal of this chain of 14 steps shall have been accomplished successfully.

SUMMARY

The 14 developmental steps previously described will, if implemented, enable the USGS NMD to progress from its present minimally computer-assisted status mapping operations to the more sophisticated and highly automated operations expected to be required for such activities in the future. This progress is made possible by recent advances in electronic computer graphics technology, and by recent acquisition by NMD of some of this new technology. Many of the software components needed for this developmental effort already exist within NMD in the form of computer programs and related subroutines that have been previously developed for other mapping applications. However, a substantial amount of software and technique development remains to be achieved, particularly in the area of data base building and management, and even more particularly as it pertains to the collection and periodic updating or other maintenance of the Division's mapping status accounting or inventory information.

The approach proposed admittedly encompasses a substantial amount of developmental effort. However, the advantages to be gained through implementation of such an effort, however large, are seen as far outweighing the disadvantages that are to be accrued as a consequence of not doing so. A prime example of the benefits to be derived from the more highly automated approach proposed is more current and up-to-date mapping status information in a form that can be easily and rapidly accessed by NMD personnel as needed for making highly knowledgeable and perhaps complex technical recommendations and managerial decisions related to both long- and short-range future NMD mapping programs and operations. Indeed, these more sophisticated and more highly automated status mapping activities may well prove to be essential tools for future program managers faced with the task of providing more map products of better quality with less people and financial resources.