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in this issue

Letter from the Editor

Dear Members of NACIS,

Welcome to *CP*50, the first issue of *Cartographic Perspectives* for 2005. It's December 20, 2004…a foot of snow on the ground here in Duluth…Dvorak's New World Symphony is blasting out of my JBLs here in my office…my secretary has rolled her eyes at me at least 5 times already this morning (and has shut my door twice)…and I am wearing my favorite geo-t-shirt that says "as a matter of fact, the world does revolve around me". Life is good. If I were done grading my mountain of final exams, life would be grand. I'll settle for good.

This year is a reflective year for NACIS, and subsequently a reflective time for *CP*. As a collective academic body, we mourn the loss this past year of Professors David Woodward and Arthur Robinson, who passed away on August 28th and October 10th respectively. A *Special Issue* of *Cartographic Perspec-*

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about the cover

The cover image was created by Louis Cross at Florida State University.

Jacksonville is the largest city in the continental United States by area covering 841 square miles and was host to Super Bowl XXXIX held February 6, 2005. Fighting for the chance to host the Super Bowl in the small market of Jacksonville, the planning committee used simple maps to communicate how the shortage of lodging and restaurant outlets in the downtown area would be solved. An innovative plan to dock 5 cruise ships along the riverfront closed the deal with the NFL.

The underlying image uses a USGS DEM. The white rectangles represent the 6 bridges crossing the St. Johns River. The water features on the map have been cast in a golden hue to represent the 50th issue of *CP*.

(*letter from editor continued*)

tives, that celebrates and honors the accomplishments of these two men, is currently in production. I anticipate that this issue will be published as *CP*51 in May of 2005.

Two-thousand Five also marks the 25th anniversary of the North American Cartographic Information Society. Those 25 years went by awfully fast, did they not? In observance of this anniversary, *CP*52 will review the last 16 years of its publication, from the perspective of each of the past three editors (can you name them?), as well as from the perspective of the current editor (can you name me?). Here are some small tidbits of temporal information leading to the birth of *CP*. *Cartographic Perspectives* was first published in March of 1989 with co-editors David DiBiase and Karl Proehl. Prior to this time, NACIS first published 23 issues of *Map Gap* (edited by Karl Proehl), and then 8 issues of *Cartographic Information* (edited by Ruth Anderson Rowles). Then *Cartographic Perspectives* was pushed into the world, so to speak. The NACIS Publications Committee, in 1988 (or there 'bouts), said that the purpose of *CP* "should be to publish papers and information that support the stated objectives of the Society and to serve as a record of the Society's activities" (DiBiase, 1989, Message from the Editors, CP1). I can confidently say that *Cartographic Perspectives* has, and continues to fulfill this purpose.

It has been fun (and educational even) for me to pour through the past 49 issues of *Cartographic Perspectives*. The journal has certainly grown and matured over the past 16 years. It has shed much of its newsletter-kinds-of-information role from its early years, assuming a more formal position among other cartographic research journals. At the same time, *CP* has retained some of the informal aspects that have made it a successful record of the Society's activities. It has remained an inclusive publication, representing the broad diversity of the NACIS membership. *CP* continues to publish technical "how to" pieces. *CP* includes current news and issues central to the archival, storage and accessibility of all forms of spatial information and data. *CP* publishes reviews of books and atlases that are of interest to the broad membership. *CP* now includes an outlet for map publishers to share their more innovative/creative maps, and it publishes the opinions of its members, even the unpopular opinions. *CP* has grown and matured along with NACIS. It remains "a forum every member feels comfortable contributing to…that each issue contain[s] a variety of contributions from several members…[including] reviews, reports, abstracts of 'fugitive cartographic literature', notices, open letters, comments or complaints" (DiBiase, 1989, Message from the Editors, *CP*1)

Oh, and one last piece of important information. Beginning in 2005, with this very issue, *CP* will be indexed by Elsevier in GEO-BASE. This is very important for the journal, as it increases the exposure of all the content in *CP*, and therefore increases the desirability of authors to publish their work in *CP*. The editorial board of *CP* is working toward having our journal indexed in other source lists as well (e.g., Web of Science) and is considering full-text indexing.

Two-thousand Five will be a good year for *Cartographic Perspectives*. We'll have to verify this assertion in 2006.

As always, I welcome your ideas, comments and suggestions.

Warmest Regards,

Scott Freundschuh, Editor

in this issue
(continued)

Thanks to 2004 *CP* Contributors

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In Memory of Bill Loy
October 13, 1936 – November 15, 2003

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Bill Loy made a substantial contribution to American cartography, not through any theoretical breakthrough, nor through the development of a traditional grant-based research program, but instead through the cumulative effects of his personality. Bill left a legacy of two admired state atlases, a vital university cartography lab, and students whose maps are ever prevalent in American cartography. His career, and his accomplishments were a testimony to the long-term efficacy of gentle determination.

Bill was, literally, a Boy Scout. He actually wore a Boy Scout tie tack—not to mention the tie it kept in place—at many University events where the prevailing style was decidedly Left Coast Academic. He was a regular churchgoer, and was actively engaged in his Naval Reserve duties (in that capacity he was Commander Loy). This was not another side of Bill Loy…it is who he was.

Other renegade Boy Scouts, like me (I never made it past Tenderfoot), will probably recall the Oath…a sort of Boy Scout catechism. As I remember it, a Scout is Trustworthy, Loyal, Helpful, Friendly, Courteous, Kind, Obedient, Cheerful, Thrifty, Brave, Clean, and Reverent. Well, in fact Bill was every one of those things. I have to admit, that's a great set of lived values in a boss and a colleague.

Bill was always ready to see the positive in someone, to see the best in someone's efforts. That generosity was frequently a problem in the mid 1970s for me and for text author Clyde Patton during the first Atlas of Oregon project. Bill would bring in some student work on an Atlas topic and propose, hopefully, that it really was pretty good, and would probably fit the bill. We would roll our eyes, throw it out, and insist that the subject had to be done better, which meant the two of us taking on yet ANOTHER page pair, from scratch. Bill would say, "Well, if you think you really can manage to find the time to do this, it certainly WOULD be better." So we always did find the time. Looking back, one could wonder whether there wasn't a Tom Sawyer-whitewashing-the-fence aspect to this, but Bill didn't work that way. Having gotten the Atlas funded, he worked tirelessly; usually seven days a week, to make sure it happened on schedule and on budget. If that meant accepting some inadequate pages, he would accept them, even if that required kidding himself that they weren't THAT bad. But, his willingness to see the best in what was delivered never blinded him to the advantages of what was better, if it was available. When the first Atlas of Oregon was a critical success, he told everyone that its high quality was due to Kai-Yu Fung's pioneer work (on the Atlas of Saskatchewan, Bill's adopted model), and to all the talent that Clyde, myself and everyone else had put into it. When pressed, he allowed that his own organizational efforts had been helpful.

Bill's positive attitude was easy to become accustomed to, and then to subsequently take for granted. Ten years after the Atlas of Oregon's first edition, I got a salutary reality check, when Allan Cartography displayed at an AAG meeting, the just-printed Raven Maps of eleven western states. The final production phase had involved fine-tuning our basic color

sequence, and duotone shading treatment for each map individually. In those pre-digital days, each map proof required most of a day's work, and hundreds of dollars worth of film, proofing base, and dyes. We must have re-composited and re-proofed fifty times. By the time we got to the meeting with our maps still smelling of ink, we were deeply in hock to the bank, and physically exhausted. An eminent cartographer then marched up to the booth where we proudly displayed our wares, surveyed the maps, and made a single comment: "Why have you used the same old color scheme?" We restrained ourselves from knocking the eminent man to the floor, and, in the aftermath, began to appreciate just what an exceptionally nurturing force Bill Loy had been…and continued to be.

Bill wangled startup funding for a program in computer cartography at the University of Oregon. He believed that students needed training in the new map production techniques, and Bill wanted to be ready for an eventual second edition of the Atlas of Oregon. Bill was encouraging everyone who showed interest in cartography, and he enthusiastically promoted students who demonstrated a natural ability or gift for it. More than a thousand students enrolled in Bill's cartography courses, along with ten times as many in his other geography courses. Bill's active constructive involvement in the wider community won him the University of Oregon's Distinguished Service Award for significant contribution to the cultural development of Oregon, an honor very rarely given to faculty members.

When funding for a second edition of the Atlas of Oregon was announced in 1999, Bill had already taken early retirement (he was battling Parkinson's disease, and also felt that the next generation of cartographers needed the university salary more than he did). Never-the-less, he happily plunged back into the endless organizational and administrative work of atlas building as an un-paid volunteer. Bill felt deeply fortunate to have a second crack at such a project, this time with the full capabilities of both GIS and image processing available to the cartographer. These technologies make practically anything possible, but in the end there was still a budget and a schedule to adhere to. Bill worked tirelessly on both budget and schedule—rather, given his illness, he worked until he was bone tired, and then he kept on working. He took great pleasure from the fine work coming from the InfoGraphics Lab in the Department of Geography at Oregon State. As page pairs for the Atlas gradually emerged, Bill cajoled contributors, cheered cartographers, and kept the entire project on track. At the same time, he was perfectly clear about terminating topics that simply weren't working out. Bill asserted that we had a schedule to keep, and we were going to keep it. Gene Martin and I took on a set of population center reference maps, and were so enthusiastic about the early results that we found ourselves repeatedly expanding the coverage, until the 14 originally allotted pages had grown to over 50. At that point we realized that we would have to try to persuade Bill to consider a major change in the table of contents that he'd been devoting so much attention to. We gingerly brought up the problem, seeking to put the best face on our recklessness in pursuing a single topic to such lengths. Bill didn't hesitate a moment telling us "Go for it, that's great, it'll be a better Atlas, we'll find a way to do it."

This unexpected flexibility was in fact a classic application of a favorite Bill Loy adage: "We accept constructive criticism—if you'll construct it, we'll accept it." It also reflected his practical recognition that some contributors were not going to deliver the work they had promised. Bill was, in fact, quite realistic about this. He looked for the best in everyone, but he didn't necessarily expect it. A couple of years ago, Bill and I were discussing dissension on the Board of a large local non-profit corporation.

Bill observed that such organizations tended to develop peacefully and productively to the point of maturity—"and then things get ugly." This unsentimental clarity about good work, and the pitfalls of atlas production was typical of Bill…"dwell on the positive, but don't kid yourself…that is simply the way that things are…in the meantime, make sure you can meet your minimum commitment, then do what you can to improve on that."

In the fall of 2003, at the Portland meeting of the American Association of Pacific Coast Geographers, Bill was looking frail. He'd had surgery for cancer in a salivary duct some months before, and a recent follow-up biopsy. He explained to me that he'd have to miss a session at the conference to keep a phone appointment with his doctor. I followed him to the pay phones a while later, only to find him quietly contemplative. His doctor told him that there was reason for concern, but not for alarm. Bill and I sat for a while, and talked about this and that. During our talk, the problems of an acquaintance came up. Bill commented that the man had not been successful at much of anything—and that we, on the other hand, had done good work, had been recognized for it, and were very lucky. For us, it was a good world. Two months later, with radiation ineffective, Bill still had his eye on the positive side. He noted that he no longer had to worry about the Parkinson's disease.

Bill wrote an account of his life that was read at his planned memorial. He titled the account, "Lucky Bill".

Unusual Displays of DEMs

Three procedures for producing new ways to visualize landforms as maps or images derived from Digital Elevation Models (DEMs) are given. One procedure is used to create a highly detailed circular gray scale image from an azimuthal distribution. A second procedure utilizes the principles associated with x-ray tomography for the construction of a volumetric map from DEM cross-sectional 'slices'. The conversion of a DEM to a Digital Distance Model (DDM) comprises the third procedure, to provide 'side-looking' views of the DEM in a variety of map formats including stereograms. DEMs generated from Mars Orbital Laser Altimeter (MOLA) data were used to produce illustrations utilizing the three procedures.

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Introduction

T his article describes procedures for producing three unique ways to visualize landforms as images or maps derived from digital elevation models (DEMs). The first of these procedures generates circular gray scale, hillshade-like, images from slope directions (azimuths) without taking into account slope gradients. The resulting gray scale maps are not necessarily a pleasing description of landform but a complex one, showing every nuance of the elevation distribution. This slope gradient invariant method of pseudo hillshading is a useful approach for greatly enhancing landform detail in a gray scale display.

The second procedure described in this paper is an algorithm for DEM tomographic slicing, which produces a three-dimensional display in the form of a volumetric map (Eyton, 1997). Horizontal cross-sections of landform images derived from DEMs are printed as transparencies and then layered in register to produce a mechanical three-dimensional relief model. This low-cost method allows for the easy production of very effective 3D maps using both black and white, and color, thematic overlays.

A third procedure extracts a horizontal distance distribution referred to as a Digital Distance Model (DDM) from a vertical height distribution or DEM. Although perspective mapping software can sometimes provide an equivalent view as this 'side-looking DEM', the properties of the DDM distribution allows for a number of unique transformations and displays.

The terrain models used for demonstrating the three methodologies were obtained as DEMs generated from Mars Orbital Laser Altimeter (MOLA) data (sources for the individual data sets are given in later sections of the paper). Mars was chosen as the test site for several reasons. Principal amongst these was a geographer's/cartographer's curiosity, coupled with a compelling need to view new landscapes. Secondly, although

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earth terrain models may offer familiarity for viewers, the Martian hemisphere chosen contains earth-like features in the form of shield volcanoes and canyon lands, albeit as structures that dwarf their terrestrial counterparts. The third reason is simply an attempt to obtain an 'exploration first', even if only in cartographic form. It would be extremely exciting to be standing on the floor of Mellas Chasma looking north at the walls of the canyon as they flank the entrance to Condor Chasma. If that is impossible, then the next best thing is to provide the 'same' view in the form of an image cartographically derived from the MOLA data; when you are looking at Figures11 and 12, you are 'standing' on Mars!

Literature Review and Origins

There is no single set of literature that can be pointed to as the background for the derivation of the three disparate methodologies described in this paper. Each is based on completely different principles coming from separate tracks within the evolution of digital cartography and from other fields as well. If an overview of terrain mapping is desired it can be found in Thelin and Pike (1991) under the headings "Visualizing the Landscape", "Machine Images of Topography", and "Application of Digital Landform Maps", within this well written paper accompanying U. S. Geological Survey Map I-2206.

". . . the circular grayscale mapping methodology . . . is more firmly based on attempts to map directional data in several forms including illuminated contours."

At first glance the circular grayscale mapping methodology appears to be another type of hillshading but is more firmly based on attempts to map directional data in several forms including illuminated contours. Kennelly and Kimerling (2001) present a useful discussion on "Developments in Illuminating Contours" with reference to the relevant work by Tanaka (1950), Horn (1982), Imhof (1982), Gilman (1973), Puecker *et al*. (1975), Yoeli (1983), and Eyton (1984). The approach I used in this paper to produce an azimuthal grayscale image was based on my 1984 digital implementation of illuminated contouring that used three tones; black for those portions of contours with sun-opposing azimuths, white for those portions of contours with sun-facing azimuths, and middle gray for the background. The procedure for circular grayscaling developed here is essentially an expansion of this three-tone technique to a full, continuous tone method for displaying slope azimuths. The results are very detailed, hillshade-like, looking displays.

"The tomographic mapping methodology presented in this paper has its roots in image displays that are referred to as 'Slice-Stacking Displays' . . ."

The tomographic mapping methodology presented in this paper has its roots in image displays that are referred to as "Slice-Stacking Displays", in Section Ten of The International Society for Optical Engineering Milestone Series, *Selected Papers on Three-Dimensional Displays* (Benton, 2001). Cartographers are more familiar with this methodology in terms of simple landform models constructed by elementary school students from topographic map contour cutouts that are stacked one on top of another. I published (Eyton, 1986b) a simple computer algorithm for generating contour templates from a DEM that could be glued to poster board, and then manually cut out and stacked to produce a solid relief model. Much more detailed volumetric models are now being generated (Sandin, Topmiller, and Weaver, 2002) from laser cut high-density plastic foam with inkjet printed overlays (eg. land use, satellite images, hypsometric tints) although at some expense. The low-cost method for producing three-dimensional maps with black and white or color overlays offered in this paper is based on the algorithm given in my 1986b paper. I have again essentially expanded on an old methodology that produced contour templates (without overlays) in three tones (black, white, and middle gray) to a methodology that uses continuous tones to produce the templates with a monochrome

or color overlay. The cost to print and assemble each model is less than five dollars.

The third methodology presented in this paper, the transformation of the elevation distribution found in a DEM, to distance distribution called a DDM has tenuous ties to the cartographic literature. It is simply a different method for presenting the information in a DEM and at best is related only to the hidden line algorithm found in a graphical approach called wire frame perspective plotting embodied in programs such as the Laboratory for Computer Graphics and Spatial Analysis SYMVU package (Harvard University, 1971). A program of this type was modified (Masters and Contino, 1983) to produce color separations so that an overlay (annual average temperature in one example and land use in another example) could be generated as wire frame perspective plots (Eyton, 1986b). I was intrigued by a limitation of this particular implementation that prevented the creation of perspectives with viewing altitudes of zero degrees; you could not obtain a display of the terrain model as if you were standing on the ground. In addition to a having a zero degree viewing altitude I also wanted to be able to simultaneously induce parallax in order to view a landscape from a horizontal perspective in stereo. It is these two parameters that set me to thinking about the needed transformation over many years and like many ideas worked on over a long time, the solution just recently presented itself suddenly, and is reported as the DEM to DDM transformation in this paper. The application of the transformation to a DEM produces a new data set (DDM) that can be manipulated (eg. spatial derivatives, lighting models, and parallax induction) and mapped (eg. grayscales, contours, and hillshades).

General Methodology

The three techniques described in this paper have no methodologic commonality other than how each procedure is applied to a data grid. Raster processing (Peuquet, 1979) was used to operate on image grids containing one byte gray level values varying from 0 to 255, or on terrain model grids containing floating point numbers representing elevations, slope gradients, slope azimuths, or relative radiance values. Each grid was processed from top to bottom (first row to last row) and from left to right (first column to last column) on each row; no windowing or neighborhood processing was involved.

The algorithms were coded as FORTRAN 77/90 executables running under WINDOWS XP and 'styled' so that they could be included in a teaching package of programs (TERRA FIRMA) that have been written for use in undergraduate senior level courses in digital remote sensing and digital terrain modeling at Texas State University (see Table 1). This package accomplishes most of the basic processing needed by students in these principles-driven courses. The learning curve is 'gentle', students can retain a copy of the software after they finish the course, and because the emphasis is on understanding rather than 'button-pushing' students have very little difficulty migrating to the more complex commercial remote sensing and terrain modeling software packages.

Two map projections that are easily implemented as raster processing algorithms while preserving the circular shapes of craters were utilized to produce the images in this paper (Snyder, 1987). A simple sinusoidal projection was used to minimize distortions on the hemisphere data sets and involved scaling each row of the image as a function of the cosine of the latitude. An equidistant cylindrical projection was used for the smaller

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subset and again involved a simple resizing of the image on each row equally.

DATA
SUBCON   - subsetting and data-type conversion
JOIN   - horizontal or vertical merging of grid data files
FMR   - flipping, mirroring, and 90° rotations of grid data
ENRED   - grid enlargement or reduction
RESOLVE   - ground resolution for arc-data grid cells
RAW   - display of numeric values for a 5x5 neighborhood

MAPPING
GRAY   - continuous and classed gray scale maps
CONTOUR   - binary, edge, and illuminated contour maps
RGB   - continuous and classed color maps
PALETTE   - color palette generation
MASK   - threshold masking
PROJECT   - equidistant cylindrical and sinusoidal projections
AGRAY[1]   - circular gray scale
ARGB   - complementary color azimuthal class map
VOLMAP[1]   - volumetric maps from tomographic slicing of DEMs

TRANSFORMATIONS
ALGEBRA   - algebraic, trigonometric, and logical manipulations
CONVO   - 3x3 neighborhood convolution including filtering and differentiation
ACONVO   - 3x3 convolution of circular data including filtering and differentiation
DERIVE   - differentiation (gradient, azimuth) of arc-data
STEREO   - parallax induction
LIGHT   - relative insolation (Lambertian lighting models)
FLOW   - steepest descent DEM flow frequencies
DDM[1]   - conversion of a DEM to a Digital Distance Model

STATISTICS
COUNT   - frequency table and histogram for grid data
QCOUNT   - display of clipping levels, break points, and extremes
STATS   - descriptive grid statistics
REGRESS   - reduced major axis bivariate grid regression
EIGEN   - principal components analysis; eigen-grid output
ASTATS   - descriptive circular statistics and frequency table

IMAGE PROCESSING
SIPROC   - special imaging procedures including level-sliced CIR composites, synthetic principal components analysis, and simulated normal color
TRAIN   - unsupervised training-field selection
CLASS   - classification
CONTEXT   - varying window size convolution to produce contextual image files
TRAIN2   - unsupervised training-field selection from contextual image files
CLASS2   - classification of contextual image files

[1] algorithms given in this paper

Table 1. TERRA FIRMA Package of Programs

Circular Gray Scaling

Azimuths as calculated by Eyton (1991) indicate the down-slope direction of the gradient or the direction of the maximum slope magnitude as the elevation changes from high to low. The resulting distribution extracted from a DEM is circular, varying from 0° - 360°, and therefore cannot be mapped using conventional linear gray scaling. A simple circular gray scale can be used to map this distribution, so that azimuths pointing directly at an illumination source will be considered fully lit and assigned a gray level value of 255 (white) and those azimuths pointing directly opposite or 180° from the illumination source are considered unlit and assigned a gray level value of 0 (black). All other azimuths are scaled systematically between 0 and 255 on either 180° half of the user selected illumination direction (solar azimuth). Figure 1 shows the scaling for both a 360° illumination source and a 315° illumination source; the algorithm for producing either of these distributions is given in the following three step procedure:

"The resulting distribution extracted from a DEM is circular, varying from 0° - 360°, and therefore cannot be mapped using conventional linear gray scaling. A simple circular gray scale can be used to map this distribution . . ."
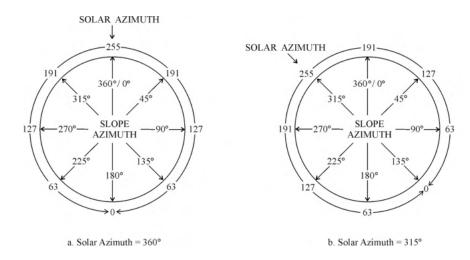
Figure 1. Circular gray scaling (gray level values from 0 to 255) for a 360° illumination source and for a 315° illumination source.

Step 1: Determine the absolute difference (AD) between each slope azimuth (SLPA) and the user selected solar azimuth (SOLA).

AD = •SOLA - SLPA•

Step 2: If the absolute difference is greater than 180, then redefine AD by subtracting the absolute difference from 360.

IF (AD > 180.) THEN AD = 360. - AD

Step 3: Calculate the brightness value as a gray level value (GLV from 0 to 255).

GLV = 255 - [(AD/180) x 255]

The algorithm works for all user selected solar azimuths and all DEM derived slope azimuths including 0° and 360°. For perfectly flat terrain

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"... flat areas often are not truly flat and consist of very gently sloping regions that show only very small variations in gradient while exhibiting an irregular distribution of down-slope directions or azimuths. The result is a rough or 'bumpy' looking plain when displayed as a circular gray scale image. A comparison of an azimuthal circular gray scale image to a conventional hillshaded image explicates this point."

(slope gradient = 0°) that have no slope azimuth, a gray level value of 127 is arbitrarily assigned to produce a mid-level gray tone in the image.

Figures 2 and 3 show gray scale maps of the slope components (gradient and azimuth) for one half (180°E to 360°E) of the 1/16° x 1/16° resolution DEM (2880 x 2880) found in the Initial Experimental Gridded Data Records (IEGDR) as data file IEG0062T.IMG (Planetary Data System <u>Geosciences Node</u>, 2002) derived from the Mars Orbital Laser Altimeter (MOLA) data.

The slope gradient map (Figure 2) was produced by transforming the gradient component values to a gray scale of 0 (black for flat land) to 255 (white for the steepest slopes). The algorithm for producing the circular gray scaling scheme shown in Figure 1 was used to produce the image of the azimuth distribution shown in Figure 3 that displays all changes in relief, large or small, with approximately the same amount of detail. For example, flat areas often are not truly flat and consist of very gently sloping regions that show only very small variations in gradient while exhibiting an irregular distribution of down-slope directions or azimuths. The result is a rough or 'bumpy' looking plain when displayed as a circular gray scale image. A comparison of an azimuthal circular gray scale image to a conventional hillshaded image explicates this point. The hillshaded
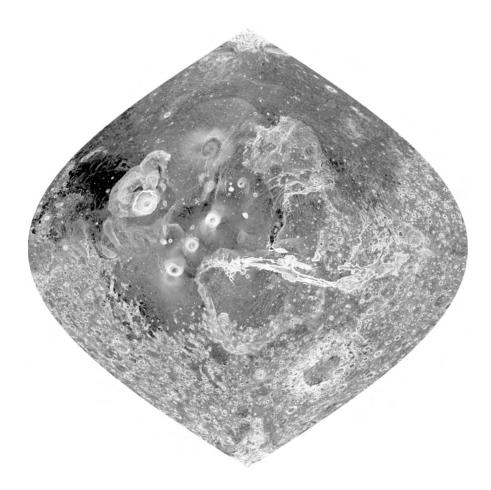
Figure 2. Linear gray scale image of the slope gradient distribution for the 180°E to 360°E hemisphere of Mars. Low slopes are dark toned and high slopes are light toned. Olympus Mons appears in this image as the west-most shield volcano with a circular cone (excluding the lava field) roughly 550 km (342 mi) in diameter. Valles Marineris, the 'Grand Canyon' of Mars, begins just east of the three southwest to northeast (Arsia Mons, Pavonis Mons, and Ascraeus Mons) aligned volcanoes and ends 4300 km (2672 mi) to the east. Projection is Sinusoidal.
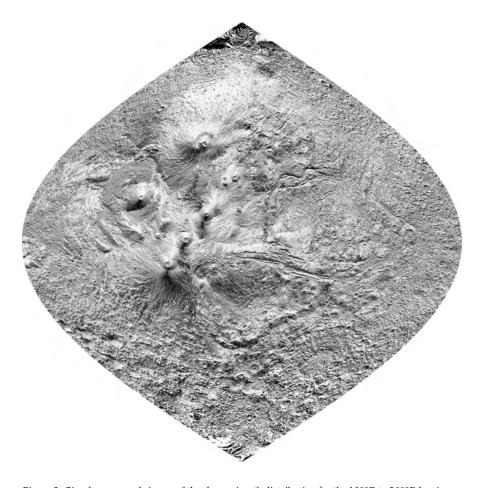
Figure 3. Circular gray scale image of the slope azimuth distribution for the 180°E to 360°E hemisphere of Mars. Lighting is from the north (solar azimuth=0°). Projection is Sinusoidal.

image shown in Figure 4 uses an incident insolation calculation (Donker & Meijerink, 1997) to determine the relative radiance (0.0 - 1.0) for each grid cell in the Martian DEM. The slope gradient and the slope azimuth of each grid cell along with the user selected solar azimuth (0º - 360º) and solar elevation (0º - 90º) are used to calculate the relative amount of solar radiation striking the Martian surface for any grid cell of the DEM. A linear scaling of the relative radiance distribution from minimum (GLV = 0 or black) to maximum (GLV = 255 or white) produces a Lambertian hillshaded image in which the plains now appear smooth and flat.

Other characteristics of the circular gray scale image shown in Figure 3 include the 'plastic-like' appearance of those regions, such as the flanks of the Tharsis shield volcanoes, where there is a systematic and smooth change in azimuth that defines the sides of the cones. Emphasis on every break or edge in the landforms, regardless of magnitude, is the hallmark of the circular grayscale display; no other mapping transformation that I have used produces this level of detail.

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Tomographic Mapping

Tomography is a technique usually associated with medical X-ray scans of the human body. The New World Dictionary of the American Language (1984) offers this derivation - "*Tomo* is from the Greek *tomos* which means *a piece cut off*", and definition - "a technique of X-ray photography by

Figure 4. Hillshade image created by the linear gray scaling of the relative radiance distribution for the 180°E to 360°E hemisphere of Mars. Lighting is from the north with a solar azimuth=0° and a solar elevation=45°. Projection is sinusoidal.

". . . the additive density of the material makes it difficult to see detail on the bottom layers. The limiting number of sheets controls the number of elevation classes that are selected and in order to add contour lines equal interval classes are required."

which a single plane is photographed, with the outlines of structures in other planes eliminated". A procedure based on this definition was used to construct cardboard landform relief models (Eyton, 1986b) from computer-generated templates. This procedure has been modified to produce images generated from DEMs as horizontal transparent slices of the earth's surface that can be stacked in a three-dimensional volumetric black and white, or color, display.

Figure 5 shows a hillshaded image of Olympus Mons derived from the $1/64°$ x $1/64°$ DEM (1000 x 1200) subset obtained from the Mission Experimental Gridded Data Records (MEGDR) as the MEGT45N090G. IMG data file (Planetary Data System Geosciences Node, 2002). The elevation range for the DEM was divided into nine equal-interval classes and those portions of the hillshaded image that fell into each elevation class were printed as separate images (see Figure 6) onto overhead transparency media. About nine or ten sheets appear to be the maximum number of transparencies that can be used in a stack; any more, and the additive density of the material makes it difficult to see detail on the bottom layers. The limiting number of sheets controls the number of elevation classes that are selected and in order to add contour lines equal interval classes are required. Table 2 shows the classes I chose to slice the elevations from the Olympus Mons DEM while adding contour lines at a 3000 m interval.

The overhead transparencies were attached to overhead transparency cardboard mounting frames and then stacked on top of each other in
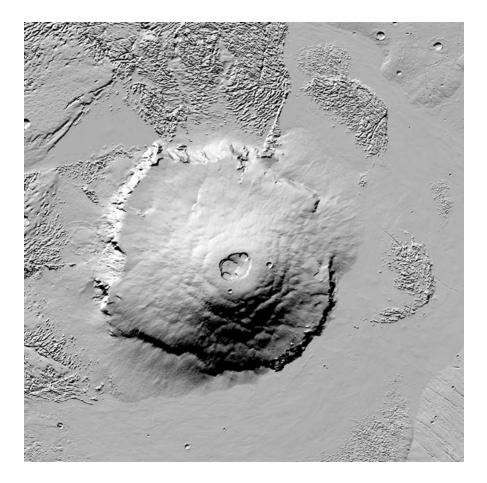
Figure 5. Hillshade image of Olympus Mons derived from the 1/64° x 1/64° resolution DEM. Lighting is from the northwest (solar azimuth=315°) with a solar elevation of 45°.

register to produce a mechanical volumetric model. Persistence of vision blends the individual layers into a continuous three-dimensional display that can be examined from any direction without the use of special viewing aids. The same procedure can be applied to other images, such as satellite scenes, land use maps, temperature distributions etc., registered to a DEM, to produce volumetric maps with black and white, or color, thematic overlays.

The principal drawback to this mapping approach is that the images printed on the overhead transparency material, when stacked, become difficult to see due to the additive density of multiple layers. A simple solution is to attach a white sheet of paper to the bottom of the stack and hold the display up to a light source. A better solution is to fix the display onto a small light box that is mounted at eye-height on a wall. Figure 7 shows a photograph of the Olympus Mons hillshade volumetric map attached to a 9 inch x 12 inch light box.

Several alternative production methods can be used to enhance, or solve problems, with these displays. For example, vertical exaggeration can be increased by simply adding a blank transparency frame between each image layer or slice; adding two or more blank transparency mounts between each image layer will produce a display with bright spacing that appears the equivalent of white contour lines. Problems with seeing the gaps between the layers can be reduced by adding black contour lines to the hillshaded image (or other images) with a contour interval equal to the elevation class interval used for slicing. Slightly overlapping slices with

"The same procedure can be applied to other images, such as satellite scenes, land use maps, temperature distributions etc., registered to a DEM, to produce volumetric maps with black and white, or color, thematic overlays."

". . . vertical exaggeration can be increased by simply adding a blank transparency frame between each image layer or slice . . ."

a. -5,000 up to -2,000
b. -2,000 up to 1,000
c. 1,000 up to 4,000
d. 4,000 up to 7,000
e. 7,000 up to 10,000
f. 10,000 up to 13,000
g. 13,000 up to 16,000
h. 16,000 up to 19,000
i. 19,000 up to 22,000
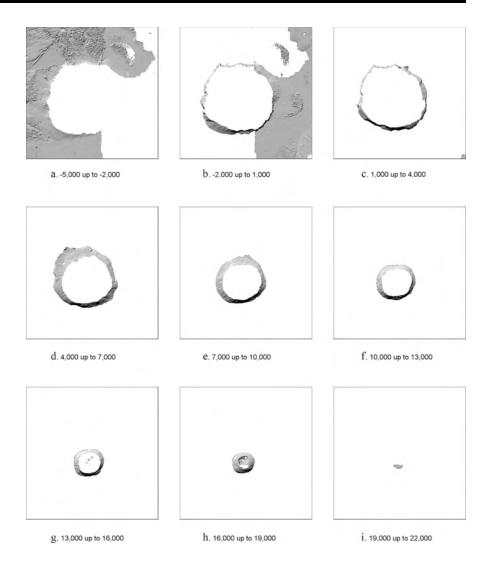
Figure 6. Slices of the hillshade image shown in Figure 5 using a reference location= -5000m and an elevation class interval=3000m were used to produce these nine images.

Elevation Class	Lower Class Limit	Upper Class Limit
1	-5000	<-2000
2	-2000	<1000
3	1000	<4000
4	4000	<7000
5	7000	<10000
6	10000	<13000
7	13000	<16000
8	16000	<19000
9	19000	<22000

Notes
The actual extremes for the Olympus Mons DEM are as follows:
   Z-minimum = -3264 m
   Z-maximum = 21229 m
The class interval for the tomographic slicing was set at 3000.

Table 2. Elevation Classes for the Olympus Mons Tomographic Map

feathering at the edges is another alternative for creating a smooth transition between the image segments of the display.

Figure 7. The nine image slices shown in Figure 6 have been attached to overhead transparency frames, interleaved with blank frames, and stacked in register to form the volumetric map displayed above.

Digital Distance Models

A transformation that converts the vertical height distribution of a DEM into a horizontal distance distribution that I call a digital distance model (DDM) provides the basis for a number of unique measurements and displays. Figure 8 illustrates how the process works using a small 3 x 5 DEM and the resulting 10 x 5 DDM. The small amount of easy to read FORTRAN code used to extract the DDM from the DEM is given as well. The algorithm may be more readily understood as a graphic (see Figure 9) that illustrates the relationship between the DEM and the DDM for the transformation of the first column of elevation values in the DEM, to the first column of distance values in the DDM. A subset of the Mars 1/64° x 1/64° DEM (1000 x 1200) found in the Mission Experimental Gridded Data Records (MEGDR) as the MEGT00N270G.IMG data file (Planetary Data System GeosciencesNode, 2002) centered on the Melas Chasma region of Valles Marineris was converted to a DDM (150 x 1200) then displayed as gray scale images to illustrate the process. Figure 10 shows a hillshaded image with a white line bisecting the valley walls that contain the Mellas Chasma where it opens to the north into Condor Chasma and then into Ophir Chasma. In order to obtain an unobstructed view of the valley wall north of the line, all elevations in the DEM south of the line were set to the elevation value occurring at the intersection of the line. The DDM was created by looking from the south of the modified DEM to the north. A slope gradient transformation was used on the DDM before gray scaling to produce the horizontal view shown in Figure 11a. The slope gradient

"A transformation that converts the vertical height distribution of a DEM into a horizontal distance distribution that I call a digital distance model (DDM) provides the basis for a number of unique measurements and displays."

```
              GRID CELLS (COLUMNS)

                1    2    3    4    5

            1   52.  68.  76.  30.  21.
   ROWS     2   36.  53.  32.  25.  21.      DEM (3X5)
            3   23.  34.  42.  21.  21.
```

```
              GRID CELLS (COLUMNS)

                1    2    3    4    5

           10   0.   0.   0.   0.   0.
            9   0.   0.   1.   0.   0.
            8   0.   1.   1.   0.   0.
            7   0.   1.   1.   0.   0.
ELEVATION   6   1.   2.   1.   0.   0.      DDM (10X5)
 CLASSES    5   1.   2.   1.   0.   0.
            4   1.   2.   3.   0.   0.
            3   2.   3.   3.   0.   0.
            2   2.   3.   3.   2.   0.
            1   3.   3.   3.   3.   3.
```

```
C FORTRAN PROGRAM TO TRANSFORM EXAMPLE DEM TO DDM
C
      REAL*4 DEM(3,5),DDM(10,5)
      DATA DEM/52,36,23,68,53,34,76,32,42,30,25,21,21,21,21/
C
C ASSIGN PARAMETERS
      NROWS=3
      NCOLS=5
      NCLASS=10
      NCLASS1=NCLASS-1
      ZMAX=80.
      ZMIN=20.
      ZRANGE=ZMAX-ZMIN
C TRANSFORM DEM TO DDM
      DO I=1,NROWS
        DO J=1,NCOLS
          NZR=(ZMAX-DEM(I,J))/ZRANGE*NCLASS1+1.5
          DO II=NZR,NCLASS
            DDM(II,J)=I
          END DO
        END DO
      END DO
C WRITE OUT DISTANCE VALUES FROM DDM(II,J)
      DO I=1,NCLASS
        WRITE(*,'(5F5.0)') (DDM(I,J),J=1,NCOLS)
      END DO
      STOP
      END
```

Figure 8. The relationship between a DEM and an extracted DDM is presented using a small example data set. The FORTRAN code used to create the 10 x 5 DDM from the 3 x 5 DEM is listed below the diagrams.

for the DDM was determined using the zero distance plane as the base reference. For areas that show no terrain (above the top of the valley) the slope gradient as measured against the zero distance plane will be zero
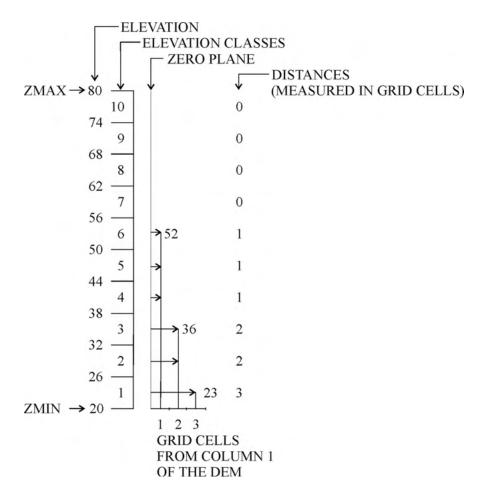
Figure 9. This graphic shows the relationship between the first column of the 3 x 5 DEM and the first column of the 10 x 5 DDM from a left side, horizontal point of view.

degrees and appears dark toned (black) in a gray scale map; slopes greater than zero will appear light toned.

The resulting display, which has an abnormal appearance, similar to that of a film negative image, can be altered by reversing the tones to produce the 'positive' image shown in Figure11b. Flat (as measured against the zero distance plane) or nearly flat areas will now be light toned and steeper areas will now be dark toned. This image has an ink-sketch quality that I believe portrays the landscape in a more normally accepted rendition.

Other transformations and mappings of the DDM can provide useful displays as well. Contouring the DDM will produce a series of cross-sectional profiles; gray scaling the DDM will produce a display that is reminiscent of the actual view, paintings, and photographs of the various foreground to background planes of terrestrial foothills and mountains when observed from afar. Parallax induction is another transformation that can be easily applied to a DDM to produce a unique graphic in the form of a stereogram. North and south looking DDM subsets (150 x 290), centered on the arrows visible in Figure 10 were used to produce left and right parallax induced DDMs before transformation into the slope gradient gray scale stereograms shown in Figures 12a and 12b. The parallax induction algorithm is exactly the same as the one used to generate stereograms from DEMs as given by Eyton (1984).

"Contouring the DDM will produce a series of cross-sectional profiles; gray scaling the DDM will produce a display that is reminiscent of the actual view, paintings, and photographs of the various foreground to background planes of terrestrial foothills and mountains when observed from afar."
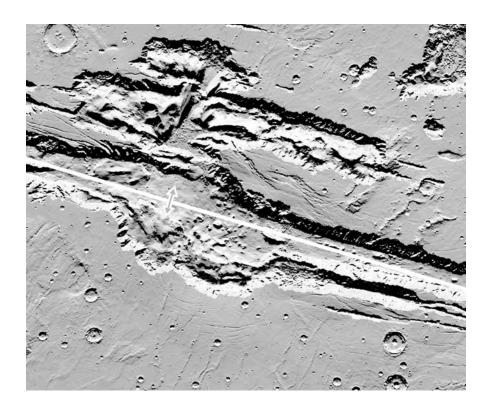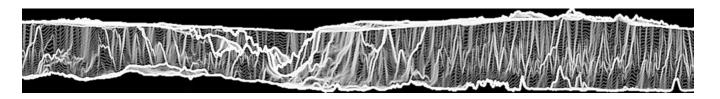
Figure 10. This hillshade image of the central region of Valles Marineris was created from a subset of the Mars 1/64° x 1/64° DEM. The white line bisecting the image into north and south halves corresponds to the location in the DEM where all elevations to the south of the line (along the columns in the DEM) were set to the elevation value occurring at the line. The DDM and resulting images (Figure 11) constructed from this altered DEM shows only detail north of the line. The arrows, located roughly at the center of Mellas Chasma, show the middle location of two additional DDM subsets that were used to create the stereo images shown in Figure 12. The north arrow points to the entrance of Condor Chasma and following the arrow's direction also points to the entrance of Ophir Chasma located immediately north of Condor Chasma. The area covered by this subset is approximately 1093 km (679 mi) west to east and 920 km (572 mi) south to north. Grid cell size at this latitude is about .91 km in longitude and .92 km in latitude. Projection is Equidistant Cylindrical.

a. Linear gray scale of slope gradients with flat or gentle slopes shown as dark tones and steep slopes shown as light tones.
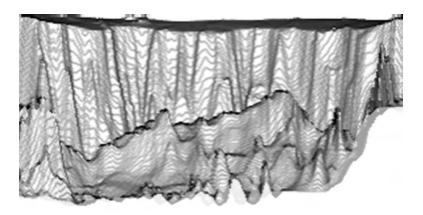
b. Linear gray scale of slope gradients with flat or gentle slopes shown as light tones and steep slopes shown as dark tones.

Figure 11. Images showing gray scales of slope gradients relative to the DDM zero plane.

a. Subset looking north through the opening into Condor Chasma.

b. Subset looking at the south wall of Mellas Chasma

Figure 12. Subsets of the Valles Marineris 1/64° x 1/64° DEM centered on the arrows shown in Figure 10 were converted to DDMs and induced with parallax before creating the left and right perspective slope images in the form of anaglyphs displayed above. Red-cyan glasses with red over the right eye are needed to view these images. (see page 60 for color version)

Discussion

Three new ways to visualize surface geometry using DEMs, with and without thematic overlays, has been presented. Circular gray scaling of a slope azimuth distribution should be of value to investigators interested in examining landform structures in great detail. However, their use as a means for popular depiction of landscapes may be limited because of the harshness of the image brought about by the same overabundance of detail that makes the displays useful for landform analysis. It is possible to mix the plastic-like image of the circular gray scale with the more diffuse-looking image resulting from Lambertian hillshading to produce enhanced hillshaded products. This is a subject of further research.

Tomographic maps have potential as teaching aids, and for providing inexpensive 3D displays that are suitable (requires no viewing aids) for public presentations in information centers. These displays, in both black and white as well as color, require no special equipment to produce but are limited in size (10 in x 12 in) to conventional overhead transparency material that can be printed on inkjet printers. Larger size models could be constructed from transparent films (50 inches wide in long rolls) avail-

"Circular gray scaling of a slope azimuth distribution should be of value to investigators interested in examining landform structures in great detail."

able for large format printers, but the mechanics of separating and stacking large images then becomes the principal problem. Layering the film between thin sheets of clear Plexiglas or acrylic plastic sheets is possible, however the resulting display would be extremely heavy.

Images from DDMs not only provide a unique horizontal view of land surfaces but also provide displays that might be considered a form of cartographic art. Their principal advantage is that the same data transformation and mapping manipulations that can be applied to a DEM can also be applied to the extracted DDM. More work needs to be done on the methodology for determining the 'height' or number of rows needed for the DDM. From my limited experience with producing these models, it appears that about ten to twenty percent of the number of grid cells or columns in the row of the initial DEM used as the number of rows to be extracted in the DDM, results in an acceptable DDM display. Application of the DEM to DDM transformation to elevation models generated from LIDAR data may produce a better balance between the horizontal resolution (not accuracy) and the vertical resolution in the DDM with the potential for creating outstanding horizontal displays from vertically gathered data.

"Images from DDMs not only provide a unique horizontal view of land surfaces but also provide displays that might be considered a form of cartographic art."

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Miscommunicating
With Isoline Preference Maps:
Design Principles for Thematic Maps

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Gould and White (1968) introduced the measurement and isoline mapping of regional preferences, producing preference or "isoeutope" maps. As cartographers know, the decision to employ isoline mapping as a cartographic display technique is valid insofar as certain assumptions are met, notably the assumption that the variable being mapped reflects an underlying continuum. This assumption is doubtful in the case of a variable such as regional preference insofar as it is based on rankings or ratings of existing regional units such as states for which human cognition is not continuous. The implications of mapping preference with isolines are discussed, particularly with respect to the attitudes the maps reflect and the cognitive responses they elicit in viewers. We argue that isoline mapping of data such as state preferences produces misleading impressions of intraregional variation and is neither necessary nor desirable. Alternative methods for the collection and cartographic display of regional preference data are discussed. Notably, we propose the use of "psuedo-Chernoff" faces as an appropriate technique.

Introduction

In a series of articles published during the 1960s, Gould and White (for example 1968) introduced the cartographic display of people's relative preferences for living in one or another region of a country. This work was subsequently developed most fully in their 1974 book, *Mental Maps*, and its 1986 second edition. Gould and White's cartographic displays provided an early demonstration that subjective, intrapsychic variables (variables that measure thoughts, emotions, attitudes, and so on) could be thematically mapped, much as one maps rainfall, population, or criminal activity.

The notion that subjective variables could be mapped was an important insight. It extended the practice of psychometrics to a geo-referenced context, allowing its cartographic expression. *Psychometrics* is the approximately century-old set of theories and techniques that allow the measurement of subjective variables that do not have direct physical referents; in contrast, *psychophysics*, well explored in cartography for decades (its history is reviewed by Montello, 2002), involves subjective variables that do have physical referents, such as color hue or perceived size (Nunnally and Bernstein, 1994). To many people, it was a revelation that such variables as fear or aesthetic preference could be quantified and mapped, and scientifi-

"Gould and White's cartographic displays provided an early demonstration that subjective, intrapsychic variables . . . could be thematically mapped, much as one maps rainfall, population, or criminal activity."

cally studied like "objective" variables. In fact, some within geography and cartography apparently still question this (for example, Walmsley and Lewis, 1993).

Early in their research program, Gould and White chose an appealing cartographic technique for displaying their preference data: the *isoline* (or isarithm) map. The isolines in this case represent lines of equal preference or liking for the places they cross; alternatively, they should be interpreted as boundaries between regions of equal preference.[1] Gould and White called them "mental maps," but we believe this term is too general because it implies a mental representation of all beliefs about places (including, for example, spatial layout) rather than a representation specifically of preference. Instead we favor the term "preference maps," or if one wants a precise technical label, we suggest they be called "isoeutope" maps. Our purpose in this paper is to review Gould and White's measurement and isoline mapping of place preferences, review some past criticisms of them, and provide a new critique based particularly on the way they communicate attitudes about preference to viewers of the maps. In the process, we make general observations about isoline mapping, and about the measurement and display of subjective variables like preference. We suggest some alternative mapping methods we think communicate better.

Figure 1 depicts an isoeutope map, based on a sample of 55 students from the University of California at Santa Barbara that we surveyed a few years ago (about 85% of them reported having grown up mostly in California). The map in Figure 1 was constructed following the methods typically used by Gould and White. First, respondents were asked to rank order regions in terms of their preferences for living there; respondents were to assume they had no financial, family, or other constraints to consider. In the case of the states of the conterminous United States, one of Gould and White's most studied areas, this results in a 48 x N matrix of numbers, the numerical ranks 1 through 48 for each of N respondents (we originally solicited rankings of all 50 states, Hawaii and Alaska being popular states, but the continuous interpolation involved in isoline mapping does not work with noncontiguous regions). The matrix was reduced to a vector via the multivariate data-reduction technique of principal components analysis (PCA). That is, each state was assigned a mean PCA score reflecting its average consensus preference by the aggregated sample of respondents. (We have found that using mean ranks instead of PCA scores is simpler, at least as theoretically defensible, and produces nearly identical maps—the two are correlated .995 in our data). The PCA scores were transformed and rescaled to range between 0 and 100, the most preferred states being assigned the highest values. Each state's mean rescaled PCA score was assigned to a point location within that state (we used spatial centroids). This spatial distribution of points was then subjected to cartographic interpolation to produce smooth and continuous isoeutopes connecting places of equal preference. This interpolation can be done formally or informally—we used inverse-distance weighted interpolation. On the resulting map, ridges of highly desirable areas and valleys of undesirable areas are evident.

We believe that isoline mapping is a poor choice for this type of data primarily because it produces misleading impressions of intraregional preference variations among viewers, especially relatively naive viewers. More than once, while gazing at one of Gould and White's maps, students in our classes have remarked that, for example, respondents obviously preferred coastal California to the Central Valley and other points east, or respondents liked the Denver area more than the mountains to the west. Even though these students were told the maps were based on single

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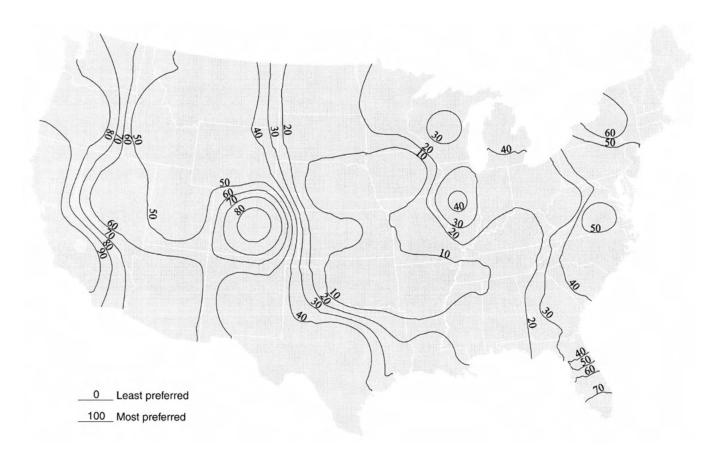
Figure 1. Isoeutope map of PCA scores from state rankings.

rankings of each state, they readily overinterpreted the maps to show variation within states that is not in the data. Being told how the maps were made, students might have realized that the high ranking of California accrues to its western edge, away from the less preferred Arizona and Nevada, while the high ranking of Colorado accrues to its center (the actual northerly location of Denver notwithstanding), away from less preferred states all around. But they did not, as we confirmed in a controlled study that found that 25 of 26 undergraduate students (only a few of whom were geography majors) shown the isoline maps mistakenly identified variation within Colorado, Florida, and California (the states we specifically asked about). This was in spite of the fact that the written instructions stated clearly that only one rank per state was assigned, and in spite of the fact that each of the questions gave students the explicit option of answering "can't tell from this map." In contrast, on a choropleth map of the data (Figure 2), an average of 18.3 of the 26 students in fact responded that they could not tell from the map whether there were variations in preference within the states of Colorado, Florida, and California (a handful of students viewing the choropleth map must have overlooked the request to judge variation "from the map"). We find these results to be quite clear, and presume that other naive viewers would respond similarly to isoline and choropleth versions of preference maps.

"Should people be educated to understand maps, or should maps be designed so as to facilitate efficient and accurate communication even among naive viewers?"

This points to an issue that has been periodically debated at least since the advent of map-design research in the 1950s (Montello, 2002). Should people be educated to understand maps, or should maps be designed so as to facilitate efficient and accurate communication even among naive viewers? We certainly don't see this as an "either-or" question. Of course

we support cartographic education, but we also support the inspiration behind map-design research that cartographers should make maps based on how people who view the maps perceive and think about the maps, and about the world. Even if cartographic education could ensure the valid interpretation of various map symbols like isolines (which is an empirical point that may not be true), maps are viewed by thousands of people who have not and will not receive this education. If anything, inadequate cartographic education is probably becoming more common. Isoeutope representation produces numerous artifactual peaks and troughs within states (or whatever the data-collection region is). These artifactual patterns are sometimes reasonable, by at least partial accident; for instance, the coast of California is generally preferred over the Central Valley, probably even by many people who live in the Valley, but what about the Sierra Nevada? In many other cases, these artifactual patterns can be very unreasonable; because California is preferred over Arizona by almost all respondent groups (perhaps by many Arizona residents too), preference within Arizona peaks in the southwest desert and drops off toward the high country in the east and north. A direct attempt to measure preference variation within Arizona would probably result in the opposite average pattern.

"A variety of criticisms and suggestions for improvement have been targeted at Gould and White's 'mental mapping.'"

Criticisms of Gould and White's Preference Mapping

A variety of criticisms and suggestions for improvement have been targeted at Gould and White's "mental mapping." Thill and Sui (1993) proposed to mathematically introduce uncertainty "fuzz" into the prefer-
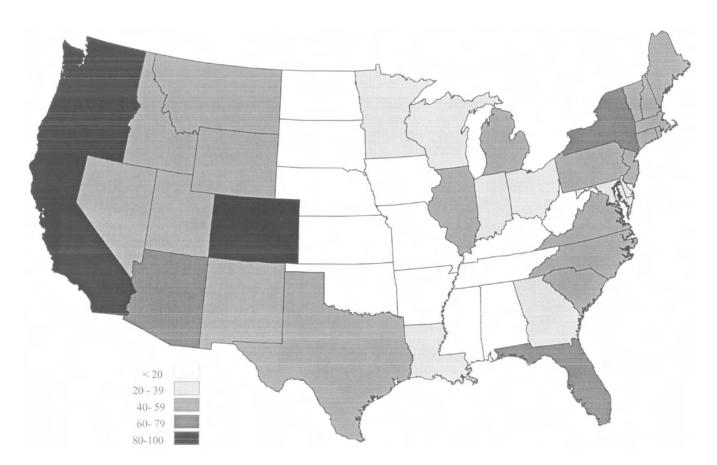

Legend:
< 20
20 - 39
40- 59
60- 79
80-100

Figure 2. Choropleth preference map of PCA scores from state rankings, based on five equal-interval classes.

ence rankings used to construct the maps, to reflect the fact that people are less certain about intermediate regions than highly favored or disfavored regions. We agree with this proposal, but note that it is rather elaborate and does not alter the basic patterns of the maps much. A simpler and more straightforward approach to the problem of ambivalent rankings, as Thill and Sui in fact suggest, would be to use a "rating" task instead of a ranking task. A rating task directly generates metric (interval-level) data and allows preferences that are nearly equal to be expressed as ratings that are nearly equal. Other writers have also focused on the meaning of the ranking task used to generate preference data. "One of the most common criticisms pertains to the expectation...to rank geographic entities in order of preference" (Thill and Sui, 1993, p. 264). Tuan's (1974) opinion was that the ranking task is a game that is unusual or unrealistic to subjects, though he believed "the maps...are an appealing way to display data" (p. 591). Gould and White themselves noted, in the preface to their second edition, that "criticism [of the first edition] focused on the viability of the ranking of spatial preferences and the representativeness of the sample of respondents" (1986, p. ix).

"Other writers have also focused on the meaning of the ranking task used to generate preference data."

The bulk of these criticisms are based on intuition rather than evidence, and we find them a bit overstated. Instead, we find it surprising that so little criticism has focused on the cartographic display of the preference rankings, including the way interpolation of data at the state level has been used to construct continuous isoline maps of preference. Our primary concern with the isoline representation of ranked preference data is that the "landscape" of underlying preference is not suitably continuous, particularly given the coarse resolution at which such data are collected. Such isoline maps communicate invalid impressions of continuous variation and intraregional variation to viewers. As is well known, interpolating a continuous surface from discretely sampled data is valid insofar as the underlying variable being mapped varies continuously across space. Put another way, the underlying variable must exhibit considerable autocorrelation, typically positive, across the surface: "The critical assumption is that events in one geographical area influence those in adjacent areas" (Tobler, 1979, p. 526). Existing literature on cartographic interpolation focuses primarily on questions of the relative validity of various sampling schemes and interpolation techniques in constructing isoline maps (for example, MacEachren and Davidson, 1987). As Lam (1983) put it in her overview of interpolation methods: "The fundamental problem underlying all these interpolation models is that each is a sort of hypothesis about the surface, and that hypothesis may or may not be true" (p. 130).

"Of course it is at least as important to consider when continuous mapping techniques are valid in the first place as it is to choose the right interpolation technique."

Of course it is at least as important to consider when continuous mapping techniques are valid in the first place as it is to choose the right interpolation technique. Our main argument is that the hypothesis of an underlying continuum is sufficiently untrue in the case of regional preferences as to make isoline interpolation a poor cartographic choice for their display. There has been research on the variables underlying regional preference, much of it discussed by Gould and White in their second edition. Some of these variables (climate, topography) do vary more or less continuously. We concede that states discriminated primarily on these variables are validly mapped with isolines, although one could still criticize the sparseness of sampling only once per state when the isolines are based on state rankings (cf. MacEachren and Davidson, 1987). Other variables (laws, political climate) do not vary continuously. But more importantly, people can and do express preference rankings for regions about whose internal characteristics they know very little. A majority of

respondents from California don't know much about variation within the state of North Dakota, for instance; informal surveys taken in our classes regularly show that very few students have ever been to North Dakota. In such cases, and they are likely to be commonplace, we believe that people fall back on place attitudes and stereotypes that vary from discrete region to discrete region, but do not vary within regions. This does not invalidate the expression of preference. It does invalidate the use of discrete regional preference rankings to interpolate intraregional preference variations. Nor does the stability and consistency of the preference map patterns (noted in Gould and White's second edition, p. 63) demonstrate the validity of the interpolation procedure. It demonstrates the reliability of the preference rankings.

Regions are spatial categories. Humans commonly organize knowledge categorically in order to simplify a complex world. As such, intracategory variation is minimized and extracategory variation is exaggerated. Everyone is familiar with the inflated distinctions border residents draw between themselves and "those people over there." An apocryphal tale recounted by Muehrcke and Muehrcke (1992) nicely exemplifies categorical reasoning about regions. A man living near the Canadian-Alaskan border wasn't sure on which side of the border he lived. So he hired a surveyor, who determined that the man lived in Canada. "Thank God!" the man cried, "Now I won't have to live through another of those terrible Alaskan winters!" Anecdotal and apocryphal evidence aside, many empirical studies have demonstrated the categorical organization of geographic knowledge, whether based on maps, language, or direct experience of various kinds (Friedman and Brown, 2000; Hirtle and Jonides, 1985; Maki, 1981; McNamara *et al.*, 1989; Stevens and Coupe, 1978). In these studies, reasoning is distorted in a variety of ways (including spatially and thematically) because of its dependence on the categorical organization of geographic knowledge.

"... many empirical studies have demonstrated the categorical organization of geographic knowledge, whether based on maps, language, or direct experience of various kinds ..."

Preferred Approaches to Preference Mapping

We believe preference rankings should be displayed at the regional level at which they are collected. By and large, Gould and White discussed their maps only at the regional level; they may well have recognized that the impressions of intraregional variation created by their displays could readily be misinterpreted. In both editions of *Mental Maps*, Gould and White reported some of their earliest work on residential desirability in European countries. In these early preference maps, they did not use smoothed isoline contours to map preference rankings—they used choropleth mapping. Choropleth mapping has some communication problems of its own. The choice of intervals is often ad hoc. Especially problematic is the choropleth mapping of variables based on counts or densities of people; the "standard" red-blue choropleth maps of recent U.S. presidential elections is very misleading in this way. But preference data are not measures of person variables; they are measures of attitudes about portions of the earth surface. And in this case, we think the use of equal intervals is straightforward and defensible. So we find choropleth mapping to be an appropriate cartographic technique for these data (the data in Figure 1 are choropleth mapped in Figure 2). We agree with Sol's conclusion in a paper presented at the 1994 meeting of the Association of American Geographers: "Isolines are appropriate only when data have geographic volume and are continuous phenomena.... If a question asks for a preferred residence by state, then the data should be mapped areally, using choroplethy." The balance of her talk was a demonstration of the use

"We believe preference rankings should be displayed at the regional level at which they are collected."

of graduated circles to depict rankings of cities. Symbols such as graduated circles (and cartograms) are less appropriate than choropleth shading because preference is an interval, not a ratio, variable.

Ironically, Chernoff faces (Chernoff, 1973) might be an unusually appropriate display technique for regional preference data. Chernoff faces were originally proposed as multivariate data symbols; different parts of the face icon (eyes, eyebrows, mouth, head shape, etc.) can be independently varied so as to represent different variables. Cartographers (for example, Slocum, 1999) have proposed their use as multivariate point symbols on maps. However, in most cases the faces would probably communicate poorly because face perception is special. Upright human faces are recognized more holistically, less by part decomposition, than other types of objects, such as houses or words (Farah *et al.*, 1998; Young *et al.*, 1987). The powerful tendency to holistically perceive faces as stimulus configurations may make it difficult for viewers to extract independent values of multiple variables from the display and may lead to perceived configurations that artifactually suggest multivariate data patterns. Although the holistic perception of faces can be a strength in some cases, they probably mislead more than illuminate when particular combinations of variables cannot readily be associated with particular emotional evaluations. In an empirical study of Chernoff faces, for example, Nelson and Gilmartin (1996) found they did not work well, and concluded that research and debate leaves the question of the efficacy of Chernoff faces "still far from resolved" (p. 195). Chernoff (1973) himself anticipated "that the faces would have relatively little usefulness as a communication device" (p. 364).

The perception of unitary emotional expressions from faces is rapid and powerful, probably one reason they have been considered useful for the difficult problem of multivariate communication. A symbol system that so immediately communicates positive and negative emotions would, therefore, be exceptionally effective for communicating regional preference as a single quantity (Figure 3). Because these symbols are not functioning multivariately, we call them "pseudo-Chernoff faces."

Conclusion

Place preference is a useful geographic concept that deserves continued investigation; its assessment is a valuable exercise to geographers. Place attitudes, even when stereotypical as they often are, are part of human interaction and engagement with the Earth and with geographic information, and should help predict and explain spatial behavior such as tourism and migration. Gould and White deserve much credit for originating its systematic study by geographers. We believe this to be true even if the ranking task is difficult in some cases, or if disregarding family and fiscal constraints is, to some degree, unrealistically hypothetical.

However, if one wants to investigate and display *intra*regional variation in preference, different data-collection methods should be used. One could collect discrete rankings of subregions within the larger regions. Stimson's research on preference for suburbs in Adelaide provides an example of this approach (Golledge and Stimson, 1987, p. 288). Alternatively, one could design some type of continuous task that would allow respondents the freedom to indicate their own preference boundaries on a base map without state boundaries (for example, freehand drawing of areas). One interesting outcome of such a method would in fact be evidence of the degree to which respondents' preference boundaries ignored or attended to state boundaries.

"Ironically, Chernoff faces (Chernoff, 1973) might be an unusually appropriate display technique for regional preference data."

"Place preference is a useful geographic concept that deserves continued investigation; its assessment is a valuable exercise to geographers."

Figure 3. Pseudo-Chernoff face preference map of PCA scores from state rankings, based on five equal-interval classes.

NOTES

[1]These two interpretations of isoeutopes reflect the distinction between *isometric* and *isoplethic* (or pseudo-isoline) mapping, based on whether the mapped variable can be considered to exist at a point (like elevation) or not (like population density) (Dent, 1993; Imhof, 1972; Muehrcke and Muehrcke, 1992). Arguably, preference maps are isoplethic. However, we do not believe this distinction has any relevance to the arguments we make against any form of isoline mapping for preference data collected as state ranks.

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Large-scale Topographic Web Maps Using Scalable Vector Graphics

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With the advent of the Internet, particularly the World Wide Web, the use and demand for online maps has grown very rapidly. Large scale topographic maps from the United States Geological Survey (USGS) at a scale of 1:24,000 have been traditionally distributed in paper form. To make these maps available to a larger number of people, rasterized versions are now available from various sources. Instead of the common raster format presentation, the solution presented here is based on a vector approach using Scalable Vector Graphics (SVG), a relatively new vector format describing vector graphics for the Web. SVG provides many advantages compared to the use of a raster-based presentation, such as the quality of the graphical representation, maintenance, actualization, interactivity, and extensibility through other Web programming languages. The purpose of this research is to propose an optimal and logical structure for a SVG document with a minimal file size that would be universally applicable to all USGS large scale topographic maps while maintaining the graphic quality at a comparable level with maps presented on paper. The study shows that SVG is a promising technology for delivering high quality, fully-vector topographic maps via the Internet, both in terms of graphic quality and interactivity.

Keywords: SVG, Vector Graphics, Topographic Maps

Introduction

T he Internet has proven to be a phenomenal communication technology, bringing about new possibilities to distribute, share, and access information. For cartography, the Internet not only offers new tools for the distribution of spatial data but also new ways to present spatial data. Many authors see the Internet as the revolution in the area of cartography and GIS and point out the "irreversible" trend of this new medium (Peterson, 1999). It is estimated that more maps are distributed through the Internet than in paper form (Peterson, 2003).

The problem of disseminating spatial information through the Web is that it is a complex process involving technological, cartographic, and programming issues. Internet GIS solutions commonly make use of an underlying database to support the presentation of user-defined maps. At present, there are many Internet GIS variations that are offered by vendors. These usually work on the same general schema: database server, map server, web server and client (Peng and Tsou, 2003). However complex the underlying operation, it is the user, at his/her web browser, that is always the final consumer of the spatial information presented in map

"For cartography, the Internet not only offers new tools for the distribution of spatial data but also new ways to present spatial data."

form. Therefore, the issue of cartographic quality plays a very important role in the process of map distribution via the Web.

Besides the inclusion of basic map features, cartographic quality of web delivered maps can be understood as a complex set of operations consisting of graphic quality, interactivity, legibility, easy maintenance and manipulation with map objects. Neumann and Isakowski (2002) point out that cartographic quality is often determined by the format in which maps are distributed. Raster formats, such as JPEG and GIF, have been widely criticized for use in Internet cartography (Neumann and Winter, 2003; Held, Ullrich, Neumann, and Winter, 2004). In general, vector formats have many advantages for web mapping applications compared to raster counterparts (Kraak and Brown, 2001). Neumann (2003) proposes that the web-client data format should (1) fulfill several requirements such as superior graphical quality and interactivity; (2) be based on standards and XML; (3) not be a proprietary format; (4) allow scripting, extensibility and animation; and (5) be available for all major operating systems and browsers. A relatively new vector standard for Web graphics called SVG (Scalable Vector Graphics) can fulfill such requirements.

"Raster formats, such as JPEG and GIF, have been widely criticized for use in Internet cartography."

Most of the maps available through the Web are thematic maps, or small general reference maps. Although there are some implementations for the large scale topographic maps in raster format on the Internet, such as from http://www.Topozone.com, the cartographic quality and interactivity leaves much to be desired. Therefore, we examined the possibility of creating a vector, large-scale topographic map in SVG, and of exploring the advantages and the limitations of this technology.

This research proposes a method for creating USGS primary series topographic maps at a scale of 1:24,000 using the SVG format. The goal is to create an innovative way for delivering high-quality, interactive vector topographic maps via the Internet. It will be demonstrated that the Internet can be used to distribute maps of graphic quality comparable to paper maps. The approach described here can be applied not only to USGS topographic maps, but also to essentially any similar types of maps. It can also serve as a basis for the design of a database that would facilitate the distribution of a user-defined subset of a large-scale topographic map in SVG through the Internet.

Theoretical and Methodological Aspects

USGS Large Scale Topographic Maps

Topographic maps portray detailed information about the landscape of both natural and man-made features. They are an indispensable tool for government, science, industry, and leisure for a wide variety of purposes. The USGS (U.S. Geological Survey) provides topographic maps and updates the standard series maps in different scales for the entire United States. The map coverage has been completed for large scale maps (1:24,000), intermediate scale maps (1:50,000 and 1:100,000) as well as small scale maps (1:250,000, 1:500,000, and 1:1,000,000). Large scale topographic maps at a scale of 1:24,000, also known as 7.5-minute quadrangle maps, are the most detailed and best known USGS maps (USGS, 2003a).

"This research proposes a method for creating USGS primary series topographic maps at a scale of 1:24,000 using the SVG format."

Although large-scale topographic maps have been recently replaced by *The National Map* (a new model for geographic base information), they remain a valuable source of information, and serve as the basis for other mapping applications (including *The National Map*). Like other topographic maps, large-scale topographic maps at a scale of 1:24,000 have

been traditionally distributed in paper form. A need to distribute these maps electronically came with the advent of computers and the Internet. The topographic maps were digitized and stored in The National Digital Cartographic Data Base (NDCDB).

These maps that are the elementary part of *The National Mapping Program* (NMP) provided by the USGS, have been created and distributed based on standards (USGS, 2003b). Digitally, they are distributed in the SDTS standard (Spatial Data Transfer Standard). There are two USGS cartographic products in the SDTS standard; vector *Digital Line Graph* (DLG) and raster *Digital Elevation Model* (DEM) data.

There are several methods for obtaining DLG data for 1:24,000-scale topographic maps, either by downloading from the Internet, or ordering from USGS. A geodata searching tool *EarthExplorer* (http://earthexplorer. usgs.gov) or USGS FTP server (*ftp://edcftp.cr.usgs.gov/pub/data/DLG/ LARGE_SCALE/*) provided by USGS represents several Internet access possibilities. A series of government publications (http://topomaps.usgs. gov) provides all relevant information about topographic maps—for example, where they can be found, specific standards, data sources, and links.

SVG – A Web Standard for Vector Graphics

With the tremendous growth in the use of personal computers and the Internet in the last decade, there is a growing demand for a cross-platform, independent and standardized technology for presenting data, and for providing interoperability, evolution, and decentralization. XML (eXtensible Markup Language), originally designed and promoted by W3C, represents the answer to such demands. It is the universal standard for structured web documents, providing maximal independence of networks and platforms. It is also a key technology in the development of Web services. Simply stated, XML is regarded as the technology on which the future Web will be based.

XML legitimately found a positive response in the field of cartography and GIS in web mapping applications. For example, it was used to define a new standard that would provide spatial data encoding and interoperability called GML (Geography Markup Language). Graphic representation played an important role in this new framework. SVG, based on XML, defines a new grammar for defining 2D vector-based graphics for the Web and other applications.

SVG, a non-proprietary and a fully open standard that is based on XML, incorporating the advantages of XML technology, has brought a new light to the graphic representation in terms of graphic quality, interactivity and extensibility through other programming languages. The features and syntax for SVG is defined by W3C in the Scalable Vector Graphics (SVG) 1.1 Specification (SVG, 2003). Currently, there are many practical web mapping applications using SVG available online. They differ in technological implementation and the intended platform. It is clear that SVG is becoming a very powerful tool for presenting spatial information on the Web.

The advantages of SVG for web cartographic purposes include:

- It defines vector graphics
- It is not proprietary, but rather an open standard defined by W3C
- An XML-based technology compatible with other XML standards

"Simply stated, XML is regarded as the technology on which the future Web will be based."

"It is clear that SVG is becoming a very powerful tool for presenting spatial information on the Web."

- Text-based format, easily readable and editable by simple text editors
- Compatible with CSS, allowing for the definition of presentation attributes
- DOM access, allowing customization with JavaScript
- Extensibility with other server technologies like Java, ASP, PHP, PERL etc.
- Flexible implementation on different platforms and operating systems

Bringing Large Scale Topographic Maps to the Web

Online, large scale topographic maps provide many advantages for users. For example, because the information is provided through a server, a user would not have to rely on his/her software to process and display such information. A user may select a particular area of interest, and such information is available anywhere and anytime if the Internet connection is provided. Combined with interactive features, one could even analyze online topographic maps leading to improved decision-making. Maps provided in such a way could be used for any application that requires fast access and very detailed spatial information.

There are a number of alternatives for delivering large scale topographic maps through the Web, ranging from the simple to the very sophisticated. Static map images in raster format, even if they are scanned depictions of paper topographic maps or exported from a program in a raster format, represent the simplest form of maps for the Web. Different raster formats are used for these types of images such as JPEG, GIF, and PNG. These files can be embedded either inside an HTML page, or disseminated separately as raster images since a web browser is able to display them. This solution does not offer many possibilities for interactivity, and for the incorporation of dynamic features.

An Internet-enabled GIS represents another way to distribute maps via the Internet. While such a system requires a large server and sophisticated software, it can offer an intelligent solution for dissemination of highly interactive and dynamic maps. A database, where geospatial data is stored, plays a central role in such an implementation. However, these solutions do not always represent the best possible approach for map dissemination in terms of graphic quality, interactivity, and flexibility. At the present time, most commercial GIS systems are mainly server-based and use expensive server/Java-applet/plug-in combinations (Neumann, 2003). Each interaction with a map requires contacting a database server. This process is quite time-consuming and results in undesirable delays when querying or examining objects. Furthermore, the large-amount of client-server traffic burdens map-servers and bandwidth. Solutions based on client-side architecture using open web standards technology like SVG can bring these types of maps to the Web in an effective, inexpensive way with reliable quality. Neumann (2003) describes a procedure in which large-scale topographic maps can be delivered using SVG and open-source database technology.

There are several sites that distribute USGS large-scale topographic maps via the Internet—at present; http://www.Topozone.com is perhaps the best known. Topozone's architecture is server-side, using the open source MapServer program, and the resultant maps are in raster format.

A Case Study - Online Large Scale Topographic Maps using SVG

This study focuses on the final representation of large-scale topographic maps in SVG, rather than on proposing a complex architecture for an

"Online, large scale topographic maps provide many advantages for users."

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Internet GIS solution to deliver topographic maps. The aim is to create an online topographic map that is visually similar or even identical with the paper version, and to propose a logical document structure that is designed for further application, such as the inclusion of interactive features. The findings would be very useful for a database application that would deliver high-quality topographic maps on demand. Several steps are involved in converting existing digital topographic maps to the SVG format. These steps include (1) the processing and conversion of source data to SVG; (2) the optimization of the SVG document structure; (3) the creation of map symbology according to accepted standards; and (4) the addition of interactive features.

Processing and Conversion of Source Data to SVG

"The findings would be very useful for a database application that would deliver high-quality topographic maps on demand."

The Digital Line Graph (DLG) represents the initial source of digital data for USGS large scale topographic maps. SVG is a relatively new format, so such conversion methods have not yet been developed. Because there are no tools available for direct conversion of this file format to SVG, other methods for converting DLG to SVG have to be used.

Most GIS systems import DLG files, including both graphic and attribute data. Once imported, data can be processed, analyzed, and converted to various vector formats. Most of current desktop GIS programs also offer export possibilities to SVG. This means that DLG can be easily imported, processed, and exported to SVG using a GIS program. However, there are still several shortcomings in this process. Geometric (topological) properties of the DLG files have inappropriate impact on the resultant SVG graphics. In addition, the SVG code produced by GIS programs usually requires modifications and optimizations to the most appropriate document structure. Symbolization of map features, especially for more complex symbols, is also not very well supported. The reasons for using a GIS program for processing source DLG data can be summarized in three points:

- There are no direct import/export tools from DLG to SVG (using another program is necessary).
- Processing the source data is necessary in order to separate map objects and eliminate inappropriate topological structure of map objects (unneeded number of vertices increases the file size). The illustration on left in Figure 1 displays a line from a DLG file as multiple segments. The SVG file on the right combines these segments into a single line without any breaks that interrupt graphics.
- The separation and export of individual map objects (roads, contours, rivers, etc.) is necessary in order to assign their graphic attributes (style and symbology).

"The Digital Line Graph (DLG) represents the initial source of digital data for USGS large scale topographic maps."

The method of processing and converting source data to the SVG structure is depicted on the Figure 2. The figure demonstrates how DLG files, distributed in nine basic thematic layers, have to be imported, processed, and separately exported to the final SVG structure according to their geometric and thematic properties/affiliation. For example, spot heights (point features) and contours (line features) represent the different geometry (point/line) but the same thematic layer: hypsography. The purpose of applying this procedure is to separate individual objects in order to assign their symbology as well as prepare these individual objects for further use. This means creating the logical structure of the final SVG document.

```
<path id="rd_3_132" d="M251545.25 -
   4581596.96 L 251552.45 - 4581554.13"/>
<path id="rd_3_133" d="M 251552.45 −
   4581554.13 L 251533.15 - 4581554.13"/>
<path id="rd_3_134" d="M251533.15 -
   4581554.13 L 251552.45 - 4581612.18"/>
<path id="rd_3_135" d="M251552.45 −
   4581612.18 L 251552.45 - 4581554.13"/>
```

```
<path id="rd_3_132" d="M251545.25 -
   4581596.96l-20.73 17.6l-4.88 18.13l0.85
   11.01"/>
```
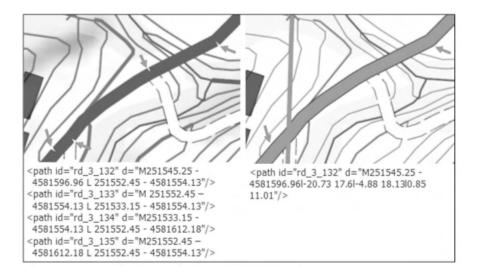
Figure 1. Inappropriate topological structure of DLG objects – unneeded number of vertices and breaks (on the left) instead of one solid line (on the right) – that have impact on the graphical representation and amount of SVG code. (see page 61 for color version)

Conversion options for exporting processed data from a GIS program to SVG differs between most commonly used GIS programs. Conversion tools offer good solutions but they still have many limitations. For example, they cannot convert more complex features such as multi-lines (a line that consists of more than one line), and symbols, that would be necessary for the creation of a large scale topographic map according to the standard symbology (USGS, 2003c).

"Conversion options for exporting processed data from a GIS program to SVG differs between most commonly used GIS programs."

SVG Document Structure

Once all map objects are encoded in separate SVG files, the process of compacting and creating the SVG document structure can be defined. The focus in this process is placed on two aspects, the optimal and logical file
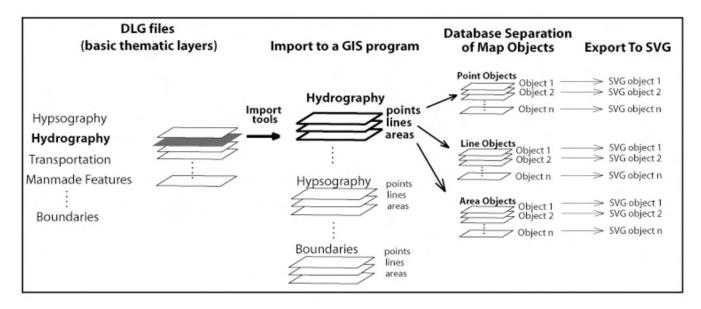

Figure 2. The process of importing, processing, and exporting source data from DLG to SVG on the example of the hydrography thematic layer.

structure that reduces the file size to a minimum and also the appropriate symbology of large scale topographic maps.

Since the SVG topographic map will be distributed via the Internet, the size of the resultant file should be as small as possible. Therefore, the structure of the code is important as it directly determines the file size. Each topographic map consists of a series of map objects that are represented by symbols. These symbols need to adhere to USGS standards. The process of SVG code optimization and minimization is divided into two parts. First, the structure of the SVG document is proposed. The second part discusses the cartographic symbols that have to be created in order to create the final map with the standard symbology.

Many things need to be considered to create a completely vector topographic map in SVG. For example, how map objects will be grouped together, what is the rendering order of the SVG document and how effectively these objects are encoded in SVG need to be given careful consideration. The topographic map contains several thematic layers including area, line, point, and text features. To avoid unnecessary overlap when objects are rendered, the order of area, line, and point objects among all thematic layers has to be established. According to SVG Specification 1.1, elements in a SVG document fragment have an implicit drawing order, with the first elements in the SVG document fragment getting "painted" first. Subsequent elements are painted on top of previously painted elements. SVG grouping elements, such as the 'g' tag, have the effect of producing a temporary separate canvas initialized to transparent black onto which child elements are painted (SVG, 2003).

The proposed SVG structure builds from the assumption that area features have to be rendered first, which means that they also have to be defined first in the document. Line features are then second, followed by point and text features. Moreover, the area, line, point, and text features that relate to the same thematic layer have to be organized in order to provide the proper rendering. The structure of the SVG document has to fulfill certain hierarchical object order (basic cartographic rules) and
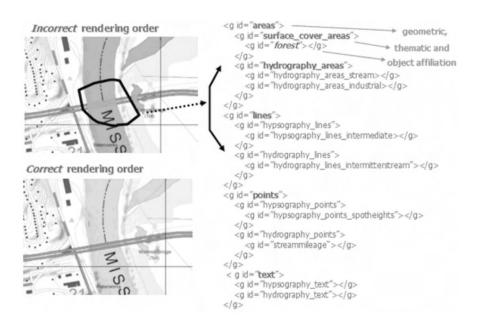

Figure 3. Example of the "overlap problem" caused by an incorrect hierarchical rendering object order with the proposed correct SVG code structure. (See page 61 for color version)

rendering order to avoid problems with display. It has been proposed as follows:

- All objects that represent the same map object are grouped, and create the lowest hierarchical level of the SVG document (e.g., all churches as map objects are grouped to create a group "church").
- All objects that relate to the same category (thematic layer) are grouped together based upon their geometry, and create the next hierarchical level. For example, all area objects that relate to hydrography are grouped together, or all point features for manmade features are also grouped together.
- Groups (objects) that represent all categories and relate to the same geometry are grouped to the highest hierarchical level (e.g., all thematic layers with area features are grouped together).
- The rendering order for the groups with highest hierarchical order is as follows: areas are defined first, followed by lines, points and then text.
- The rendering order for the different thematic categories with the same geometry is established according to their affiliation to the real surface (e.g., contours should be rendered first in relation to roads or railroads because they represent the surface, and roads are built on surface).

"To minimize code, relative instead of absolute coordinates were implemented . . ."

Another aspect that deals with the SVG code optimization is about possibilities for its minimization. Suggestions proposed by Neumann and Isakowski (2002) lead to intensive code minimization. To minimize code, relative instead of absolute coordinates were implemented, geometry was re-used when applying two or more different styles to one object, and symbols were centrally defined with styles.

3.3 Map Symbology

Cartographic symbols on 7.5-minute quadrangle maps are defined by USGS Standards (USGS, 2003c). Each symbol is defined by its size, color, placement, number, and name. Based upon these standards, it is possible to create the same symbology for map objects in SVG that are found in the paper version of topographic maps.

SVG offers many advantages for the creation of symbology for 1:24,000-scale topographic maps. Symbols can be applied to map objects in two different ways. According to a level of symbol complexity, symbology or style can be applied to a map object either directly by styles, or by using predefined symbols. The application of the SVG "style" to map objects as SVG elements is not a complicated process, and there are a variety of ways to handle such definitions. SVG offers four methods of applying style to elements:

"Based upon these standards, it is possible to create the same symbology for map objects in SVG that are found in the paper version of topographic maps."

- XML presentation attributes
- Inline CSS (Cascading Style Sheets) properties
- Internal CSS style sheet references
- External CSS style sheet references

Direct application of style (using the first two methods listed above) allows for the quickest method to test the results of style application, whereas style sheets (internal or external) allow for cleaner, more compact, and more organized documents. Since this effort is directed towards

smaller file sizes for the SVG document, CSS style sheets provide a better solution. They make the document clearer and reduce the amount of code.

"For example, a point feature, like a church or a spot height, is defined as a symbol and then it can be later referenced as many times as needed."

One of the most useful features in SVG is the ability to establish an object (or group of objects) as a symbolic group ('*symbol*' tag). By doing so, this "symbol" can be referenced multiple times throughout the document by a '*use*' tag. This is useful especially for point features. For example, a point feature, like a church or a spot height, is defined as a symbol and then it can be later referenced as many times as needed. For complex map features, such as multi-lines, which consist of several different lines with different styles, a method suggested by Neumann and Isakowski (2002) leads to a very effective solution. To create a multi-line, they propose to re-use the geometry of a single line. This is useful for instance in case of roads (class1 and class2) where lines consist of two or three styles. Figure 4 displays the code and corresponding graphic example:
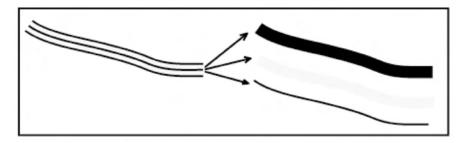

Figure 4. Multi-line composed of three styles as proposed by Neumann and Isakowski (2002). (See page 62 for color version)

Symbology for USGS large-scale topographic maps can be defined universally as a symbol library and used for any map of this type. This can be done by an external CSS file. Names of symbol classes defined in CSS should follow the "National Mapping Program Technical Instructions – Part 6, Publication Symbols (USGS 2003c)" and the particular number under which specific symbol can be found. Names should also include their geometric (area, line, point or text), and thematic (hypsography, hydrography, and so on) affiliation, based upon the rendering order in the SVG document. This could be an example of a symbol style:

"Interactive features implemented in the SVG map extend the map possibilities."

hp300line - where **hp** refers to the thematic affiliation (Hypsography), **300** refers to its number in the "National Mapping Program Technical Instructions – Part 6, Publication Symbols," and **line** refers to its geometric property.

Interactivity

Interactivity represents an important method to allow users to better extract topographic information from a web map. The number of such interactive features that can be implemented is basically unlimited and can be developed to serve specific applications. Zooming, turning layers on and off, providing coordinate readouts, and displaying attributes through mouseover functions represent basic functions that would allow interactive manipulation with a topographic map.

Interactive features implemented in the SVG map extend the map possibilities. With client-side scripting languages like ECMAScript (JavaScript), one is able to access the features SVG and every browser feature's

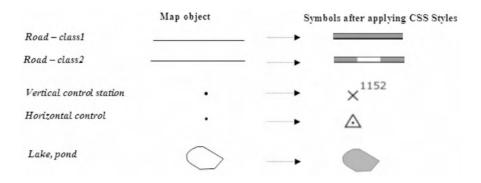|	Map object	Symbols after applying CSS Styles

Figure 5. Applying styles using CSS to create map symbology. (See page 62 for color version)

DOM (Document Object Model). Basic interactivity with the SVG map, such as zooming, panning, and resetting (returning to the original view) can be provided through the SVG Viewer, as it is currently done with Adobe's SVG Viewer (the most popular SVG viewer). However, these functions could be implemented separately from the viewer in a more sophisticated form. Using client-side scripting languages like ECMAScript, one can develop many useful interactive functions. For example, Neumann and Isakowski (2002) propose a way to implement interactive features with a SVG topographic map. They also provide a list of features that can be useful for interactive topographic web maps. Besides basic functions that serve navigational purposes (e.g., coordinates, zooming, layers on/off), they propose other functions that would allow analyzing a topographic map through the use of ECMAScript (JavaScript), such as linked elevation profile, interactive hill shading, displaying attribute data, etc.

"Basic interactivity with the SVG map, such as zooming, panning, and resetting (returning to the original view) can be provided through the SVG Viewer . . ."
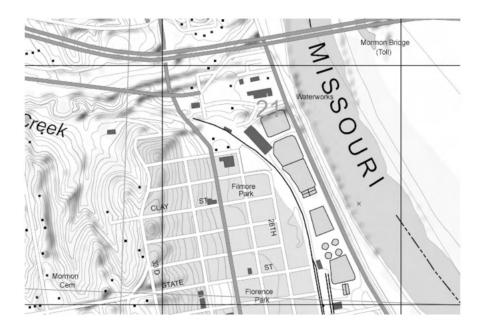
Results and Discussion

An online example of a SVG 1:24,000 topographic map with several interactive features is available at http://ptolemy.unomaha.edu/~pavlicko/. This project shows the possibilities of SVG for bringing this type of map to the Web (Figure 6). This SVG implementation was created using open-standard and open-source tools including GRASS GIS, SVG, XHTML and JavaScript (ECMAScript). SDTS data (DLG and DEM) provided by USGS served as the initial source of data for this project. Data, as it was presented in previously, was processed and exported to SVG and manually edited to the final file structure. Besides the static graphical map in a vector form, several interactive features such as toggling thematic layers "on" and "off," and UTM coordinate readout for X, Y and Z (elevation) were developed using ECMAScript.

Only a portion of a single 1:24,000 topographic map was coded in SVG. Creating an optimal file size for the Web is a very limiting factor. The information content that such maps depict, including all thematic layers, is rich, and this results in large files. The portion of the whole 7.5-minute quadrangle represented in SVG is shown in Figure 7. The size of that SVG file, not including ECMAScript coding, is 940 KB in uncompressed form or approximately 300 KB in compressed form (gzip). Depending on the connection speed, such a file in compressed form would be downloaded in approximately 10 seconds with the slowest modem connection (28.8kB/s).

File sizes for whole topo-sheets in SVG (all thematic layers) would vary, depending on the information content of the map (e.g., number of

"This SVG implementation was created using open-standard and open-source tools including GRASS GIS, SVG, XHTML and JavaScript (ECMAScript)."

Figure 6. SVG provides considerable quality of graphics (detail associated with SVG). (See page 63 for color version)

"We propose that, at a maximum, approximately only one quarter of a topo-sheet is appropriate for presentation through the Web."

contours). In order to investigate SVG file sizes, research was conducted on several 1:24,000-scale topographic maps from Wyoming, Montana, and Nebraska. These SVG files were all between 3 to 4 megabytes in size. Such large files are not appropriate for the Web at this time, but would be feasible through Point-to-Point (P2P) protocols currently implemented with music files. We propose that, at a maximum, approximately only one quarter of a topo-sheet is appropriate for presentation through the Web.

To distribute topographic maps in SVG for a larger area that may encompass many map sheets, it would be necessary to create a database that could distribute small parts of an individual topographic map on demand. Methods for delivering larger geographic datasets for large scale topographic maps are proposed by Neumann (2003).

Conclusion

This study has demonstrated that Scalable Vector Graphics (SVG) is a promising vector technology for delivering high quality interactive topographic maps via the Internet. Vector formats, in comparison to their raster counterparts, provide many advantages such as the quality of the graphical representation, maintenance and actualization, interactivity, and extensibility through other web programming languages. The corresponding implementations for the distribution of such maps in raster form leave much to be desired in graphic quality as well as interactivity.

This work has shown that it is possible to present portions of a USGS 7.5-minute quadrangle map through the Internet in SVG. This new graphic format shows great promise for the distribution of this type of map. The graphic quality and manipulation possibilities with such SVG topographic maps are far superior to corresponding raster implementations.
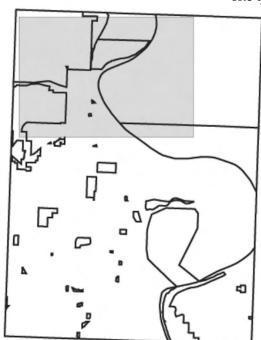

Figure 7. The area of the SVG map project (grey color) on the 7.5-minute quadrangle map (North Omaha, NE). The area represents about 1/3 of the map.

However, there are still some limitations to SVG that need to be taken into consideration. The sizes of the resultant SVG files are large. According to the results, only a portion of 1:24,000-scale topographic map sheet can be distributed, with some interactive elements. To distribute topographic maps for a larger area or encompassing many map sheets using SVG, it would be necessary to create a database that could distribute small parts of an individual topographic map on demand.

The incorporation of interactive features using client-side scripting languages like JavaScript can promote more analytical uses of these maps. The number of such features that could be implemented is basically unlimited and can be developed to serve specific applications. This represents the future challenge and an interesting subject for future research.

"To distribute topographic maps for a larger area or encompassing many map sheets using SVG, it would be necessary to create a database that could distribute small parts of an individual topographic map on demand."

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cartographic techniques

Pre-Press and Technical Support Technician

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Introduction

Creating effective, high quality maps takes a great amount of research in terms of map content, design, and production. Cartographers prepare some of the most complex digital files using a broad array of the functions in Illustration, Page Layout and GIS software. Because maps are commonly complex and require high quality output, cartographers often present challenging graphic files to their printer or publishers. From the perspective of a pre-press technician, the following topics relate to the preparation of graphic files for printing and should be of interest to cartographers:

1. File formats that are acceptable to the printer
2. Font formats, as well as a little font history
3. Color trapping for the printing industry

FILE FORMAT DESCRIPTIONS

There are several acceptable file formats that may be submitted to a printer for final publication. This section discusses these formats in terms of broader categories and conveys issues about these varying formats as they relate to publishing maps.

Customer's Software Application's Native Format

Specifically these include: QuarkXPress by Quark Inc.; Pagemaker, InDesign, and Illustrator by Adobe Systems Inc.; Microsoft® Office ; CorelDRAW Graphics Suite by COREL™ Corporation, Freehand MX by Macromedia Inc., etc.). The biggest advantage to using these formats is that the printing company or prepress department can, with cooperation of the cartographer, easily make last-minute changes to your files. These changes include modifying panels for special folding requirements, resaving files to other formats (EPS for example), or other problems with the file. By including these files when working with a printer, cartographers can save time because alterations can at times be made over the phone after review of the first proof. Be wary of printers that may make inadvertent and innocent changes or improvements to the design of the document that may "better fit" their production requirements. The printer should note and get approval for all changes that will be made to the document, prior to making those changes. Even as experience is gained in working with a particular printer it is important to have a well defined process for making changes so that surprises can be avoided.

The printer or prepress department can make the final files for printing in the formats they may prefer. These formats may favor specialized raster image processors (RIPs) rather than native EPS, Postscript, PDF, etc. The process requires hardware or software that interprets the PostScript-based files and converts them into high-resolution bitmapped graphics and images. These images are required for proofing, plating, and printing. "Bitmaps" are computer graphics composed of a defined pattern of colors of dots or pixels that make up a picture. It is a good idea to check with the printer to insure that the files used for printing are the same files RIP'd for proofing. These are the same files that should have been approved at the proofing stage of the process. If they are not, it is strongly advisable to attend the press-check to re-evaluate the entire printing form again.

If the printer is being supplied with multiple copies of the document in different formats it is absolutely critical that each copy of the map is correct. It is also a good idea to make sure the printer has the same versions of software that were used to produce the document.

All fonts must be collected and provided to the printer with no conflicts. Because some methods of copying fonts are not foolproof, test the media that is being provided to the printer.

It is important that the printer or prepress department is familiar with the use of the software applications that were used to create the map. This is especially important if the printer is not in the same geographic location as the cartographer. Several weeks can be lost if the printer is required to purchase and gain sufficient expertise to edit a map in its native file format.

Some software applications, like Microsoft® products or many desktop GIS software do not support the range of color models and publishing options that are optimal for publication. While the output of these software packages can be published, it may require substantial additional effort.

PostScript Based Formats

Encapsulated PostScript (EPS) Files: In many cases EPS files are smaller and therefore easier for

electronic transfer; although this depends heavily on the software that creates the EPS file. Because EPS files may include and embed all images, they can be easier to manage when it comes to supplying the printer with the files needed to complete your project. Because EPS is just a device-independent form of the PostScript language, it can be desirable to use because it allows a wider range of design features to be included and interpreted, like gradients. However, EPS still requires care in providing fonts to the printer because they often cannot be embedded into the EPS file. For large maps or maps that contain high-resolution images, EPS files can still be very large files. Finally, EPS files are very difficult to edit or alter, which can be a blessing or a curse.

Portable Document Format (PDF) Files: The size of PDF files can be controlled by using any of several levels of compression. This depends on which software you are using to produce the PDF files. No fonts or images files need be managed by the mapmaker if the PDF is prepared by embedding that information, which also compresses it. Furthermore, PDF files may be produced such that some degree of editing is possible, particularly with Adobe products.

PDF's can also be used for soft proofing (on monitor), as well as the ability to prepare print quality files for hard proofing and printing. See Burnett, 2004 for details on the pros and cons of soft proofing.

Publishing maps using the latest version of PDF, which is 1.6 is recommended because many past issues with PDF were improved and most printers now have the expertise to handle even the most advanced of design elements.

File Format Strategies

Problems with PDF's are very rare and therefore it is the pre-

ferred file format, but problems can still occur. Ultimately the files for most maps will need to be RIP'd. Embedded images are one item that can cause the RIP not to work. Thus, the best practice for embedding images into the files given to a printer, is to embed TIFF or EPS images into the map. Using other formats, particularly the native formats from various software packages can cause the file not to RIP. Also using LZW compression can be problematic. Another trick printers use to get files to RIP is to use Adobe Acrobat to convert the file from PDF to EPS and potentially back again. Effectively this homogenizes the file; it is something that most map makers can try as well to gauge the effects.

There are also heavier or more industrial strength remedies for files that will not RIP. Some RIPs, such as Rampage, usually can identify the problem file(s) contained in the PDF, and either the printer's prep deptartment will fix it, or the cartographer will be advised on a course of action to correct the file problem(s). Other systems are DaVince Tools by DaVince, Prinergy by Creo Inc., etc.

To deliver files to a printer, the accepted method for electronic file transfer for proofing, followed by printing is FTP (file transfer protocol). The advantages for using FTP include PC and MAC compatibility, speed of transfer, and FTP is available to everyone and easy to use.

FONT FORMATS

As mentioned earlier it is often necessary to include additional files like fonts when providing printer with the files they will need to publish a map. By understanding types of fonts and some of their basic properties it will be easier to provide a printer with what they need.

PostScript Fonts

PostScript fonts were invented by Adobe Systems Inc. and the Type 3 font was introduced in 1984 with the MacIntosh computer, PostScript language, Aldus PageMaker and the Apple Laserwriter printer. Prior to that desktop publishing was virtually nonexistent as computers were mostly used for rudimentary word processing and spreadsheets. Typically one font resided on the computer, while expensive computers had several fonts. However, nobody knew how the typed words would look until they were printed, because the on screen representation was a bitmap or scaled multiples of bitmaps; the true printer font or fonts resided only on the desktop printer.

Type 1 fonts appeared in 1989 and Adobe Systems Inc., along with other manufactures were able to produce type 1 fonts as the licensing was less restrictive. Type 1 fonts are more compact than Type 3 fonts and use special rasterization algorithms to produce better looking output at small sizes and low resoutions. Type 1 fonts include hints, which further characterize the shape of each character and are used as instructions to insure consistency of appearance (Adobe Systems Inc.).

TrueType Fonts

TrueType fonts were invented by Apple Computer, Inc. and introduced in 1991. TrueType fonts have several advantages over Postscript Type 1 and Type 3 fonts. First is characters are based on Unicode, which is a character coding system designed to support the worldwide interchange, processing, and display of written texts of diverse languages of the modern world. Second, TrueType fonts use a single font for screen display and print, as opposed to Postscript, which requires a

Screen font for display, and a Printer font for printing. The software that displays or draws TrueType fonts on a computer screen has special code to create type face effects like Bold, Italic, etc. Third, TrueType fonts allow for greater complexity in hinting of characters for on screen display and low-resolution output. This is increasingly important as web use grew in the late 1990's.

OpenType Fonts

OpenType fonts were invented by Microsoft Inc., and Adobe Systems Inc., and were introduced in 1997. OpenType fonts were developed to address the incompatibility problems of Postscript and TrueType fonts across Macintosh and Windows operating systems. OpenType fonts can contain either PostScript or TrueType font outlines (font names are suffixed .otf or .ttf respectively) and each weight is supplied as a single, cross-platform file. The .otf format seems to work best for cross-platform use. Like TrueType, OpenType is based on Unicode and therefore may contain as many as 65,000 glyphs for many languages, and may include: old-style figures, true small capitals, fractions, swashes, and a full range of ligatures.

While OpenType fonts are clearly the strongest choice from an economic and file management standpoint, the old adage of don't fix something that isn't broken still definitely applies.

One critical issue with fonts is to make sure the version of the typeface is identical. For instance archives at Image Systems, Inc. show there are four different versions for the same font, Helvetica. When publishing the printer should be clear that only the fonts supplied by the map maker should be used.

COLOR TRAPPING

Trapping digital files is the process that compensates for registration on the printing press by printing small areas of overlapping color where objects meet. The concept of trapping arises from the physics surrounding the printing process and includes: taking 4 or more plates which all contain portions or colors of the same image (file); mounting them on a printing press sometimes 80 feet long, that has high-speed spinning cylinders; printing images one on top of the other on a sheet of unstable and extremely thin paper sometimes 3 feet wide or more; and applying ink, water, and chemicals to these plates and paper at speeds exceeding 50 mph. Everything on the final, printed sheet must look sharp, appealing, in focus to the eye, and be correctly registered.

Trapping can be accomplished either manually or by means of an automated process. Most graphics or illustration software packages and page layout software offer some kind of automated trapping functionality. Printers and service providers may also have dedicated software systems for trapping. Depending on the effect that is needed, trapping for maps may

be best accomplished manually. For instance a trap of 0.002 inches will allow for compensation of any physical misregistration, while prohibiting the appearance of "keylines".

Trapping is going to produce process and media specific differences, so an effective trapping strategy for one map may not suffice for another map. The experience of the printer, cartographer, and even environmental conditions such as the temperature and humidity of the pressroom can impact the effect of trapping. In RIP Printers automatic trapping is global, creating a relationship between touching colors. The Printer can manually trap in the RIP program, if required. Whether a map requires trapping manually or by an automatic process, the cartographer should always check with the printer to verify the trapping settings.

All this said, it is possible to avoid the need for trapping. The first strategy is to not touch the colors or to use process colors in any way. This is almost always impractical because of design limitations.

A second method is knockout and overprint. Overprint is where one color is printed on top
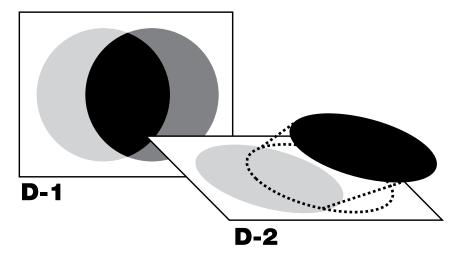

Figure 1. Note that the yellow circle isn't really a circle underneath it all. (See page 63 for color version)

of another color, resulting in an additive color. This is not desired at times. Note the color created where the black overprints the yellow in the upper left portion of Figure 1. Even when using a customer's application trapping setting, the printer may choose to globally overprint black automatically. You can anticipate this, and compensate by tricking the printers software by making your blacks that must not overprinted 100-k 1-c 1-m 1-y. Make heavy solid black areas 100-k 40-c for a deep rich black. Trap these as a normal color. Knockout-one color 'knocks out' the color underneath, but a trap is required.

Sometimes projects require special trapping regimes in order to be properly executed. If the cartographer has a full understanding of trapping, manually trapping in the applications can give desired results better than automatic trapping, but it will be time-consuming.

CONCLUSIONS

Knowledge is the key to working successfully with printers and prepress departments. This article has hopefully shown some of the common practices and best methods for cartographers to use when working with a printer to publish a map. However, this article is really the tip of the proverbial iceberg. Map makers should educate themselves prior to designing their map and especially prior to visiting their printer. Check out trade publications that publish techniques such as *The Journal of Electronic Publishing*, *American Printer* magazine, *High Volume Printing*, *Graphic Arts Monthly*, and *Newspapers and Technology*. For working successfully in color managed environments consult reference books such as the GATF Practical Guide to Color Management and Understanding Color Management by Abhay Sharma.

There are also online groups such as <u>colortheory@yahoogroups.com</u> and <u>colorsync-users-request@lists.apple.com</u>.

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map library bulletin board

Penn State University Libraries: Building a Literary Map for the Web

By Joanne M. Perry,
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With technical assistance from Derrick Beckner and Karen Schwentner
The Pennsylvania State University, Universities Library

In late summer 2000, Dr. Steven Herb, the Penn State Education Librarian and Director of the Pennsylvania Center for the Book, asked if the Maps Library would collaborate on a mapping project. Dr. Herb wanted to provide the Pennsylvania citizenry, the schools, and public libraries with access to information about Pennsylvania authors and their books in the form of a Web-based interactive map with an integrated biographical database. In other words, he wanted to design an on-line literary map. Intrigued, I agreed to assign the Maps Li-

brary's GIS support staff member, Derrick Beckner, to design the base map.

The original *Literary Map of Pennsylvania* was published by the Pennsylvania Council of Teachers of English in 1959, and revised in 1965. After nearly 40 years, Dr. Herb felt that Pennsylvania's many noted authors deserved a revised map with more authors and a greater depth of information, and he believed that the online environment was capable of delivering a much improved product.

The decision to develop an online map instead of another paper revision was both cultural and financial. The Web is where exciting things happen these days and, being practical, it avoids printing, storage, and shipping costs in the delivery of the product to the user. While the development costs of Web products are substantial, the Web also permits the use of animation, color is no more ex-pensive than black and white, and more information can be attached to online maps than can be printed on traditional paper maps. Thus, for a non-profit group or institution, the Web provides a way to transfer information to their constituents relatively economically and efficiently.

The Pennsylvania Center for the Book has a very small part-time staff, so developing the online *Literary Map of Pennsylvania* has been a cooperative venture. Sixty people at the University Park campus (5 part-time paid workers, 5 part-time interns, 8 Journalism interns, 1 Independent Studies student, 40 English students, 1 Maps Library staff member, 2 Public Relations staff members, and 1 computer technician) as well as public librarians and county historians from each of the sixty-seven counties have provided support during the development period.

In designing the literary map, Derrick Beckner used *Adobe Il-*

lustrator, Photoshop, ArcView 3.2, USGS Digital Elevation Models (DEM), and the royalty-free data set, *MapArt USA*. Karen Schwentner, the Web developer, used *Flash 5* and *ColdFusion MX* to integrate the map and the biographical database. Macromedia's *Flash* animation software was chosen as the main interface because of its ability to deliver both raster and vector images efficiently, because it dramatically reduced the amount of time spent in design and production and it is supported by both *Internet Explorer* and *Netscape. Flash* uses its own scripting language, *ActionScript*, which is similar to *JavaScript*, to dynamically integrate with Web applications.

The state-level map was developed from a stock vector map from *Map Art Deluxe-USA*. Adobe *Illustrator* was then used to modify the map's color scheme and create the heavy, county borders. The thumbnail images were optimized with *Photoshop* and then imported into *Flash*, along with the map. It took considerable time and effort to reduce sixty-seven (67) polygons, seventy plus (70+) images, and a considerable amount of text into a page of reasonable size. File size was an important issue with this project since the site is aimed towards classroom use and the general public with the expectation that neither group is likely to have access to high-speed internet connections.

The state-level maps with highlighted county boundaries were created in a similar manner, except the base maps were created from several data sources in *ArcView* before being imported into *Illustrator*. For aesthetic and educational reasons, literary information as well as geographic information were placed on a physical relief base. The down side to this decision was that it necessitated large file sizes with most of the pages being 150-200K.

File size optimization was a major challenge and it is hoped that the size of each map will be reduced to less than 100K in time for public release to enable faster loading.

The individual county maps are a combination of aerial photographs overlaid with hand-drawn, somewhat arbitrary, neighborhoods. Otherwise they were created in an identical manner to the previously mentioned maps.

This project is entering its fifth year and it is not yet completed, although it is available for public use with limited access to the biographical data. Although it is not unusual for cooperative projects supported by part-time staff to take more time than originally planned, in this case it has been the literary research that has slowed the project.

While it was clear from the beginning that the literary database was the larger part of the project, collecting this material has been more time consuming than anticipated. This has been due to the decision that each of the counties should have literary representation and each author's entry should contain a consistent amount of information. Unfortunately, authors don't choose to distribute themselves evenly across a state, they cluster, and finding standard information on all the authors, including copyright-free photographs or portraits, has been difficult as well as occasionally impossible.

Organizing the work flow or production process for a project that is dependent upon part-time or volunteer labor is not always easy, even when there is agreement that adjustments would be helpful. Derrick Beckner, the map designer, felt that he would have preferred to have all the data provided at one time rather than delivered to him piecemeal. He felt the intermittent work schedule of periods of heavy workloads under short deadlines followed

by long lulls was not efficient and collecting the data before commencing the technical work on the map might improve the overall process. He also felt that the work flow improved once Karen Schwentner, the Web designer, learned *Flash.* Forming a partnership, they divided the workload: she handled the graphics and coding work on the pages while he supplied the maps.

Ms. Schwentner noted that the potential obstacles of using Web applications are cost, accessibility, and the level of knowledge required to use the software. At the time of development, without an educational discount, the cost of purchasing *ColdFusion MX Server* was roughly $5000 with an additional $900 for the suite of software containing *Flash* and *ColdFusion Studio,* for html and cfml development.

An additional Web design focus was on integrating a means of accessibility to the page for the visually impaired. For those users *alt tags* provide textual descriptions of images that are read aloud by a text reader. At this time however, *Flash* does not provide a means to display alternative text, therefore visually impaired users cannot experience a text alternative within the *Flash* version of the *Literary Map of Pennsylvania* and must rely on a text-only version of the site in strictly html form.

Finally, knowledge of multiple software programs, in this case *Flash, ColdFusion,* an image editing program, and basic html, as well as how to integrate them, is needed to successfully complete a literary map.

Well-designed literary maps are one of the most interesting and imaginative types of maps on the market and placing them on the Internet will increase their accessibility and make them even more attractive to a new generation of users. Although it takes determination, a clear vision, and a great

deal of effort by a collection of talented and dedicated people to produce an on-line literary map it is well worth the effort.

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Pennsylvania Center for the Book, Welcome to the Pennsylvania Center for the Book <http://www.pabook.libraries.psu.edu>.

<div style="border:1px solid #000; text-align:center;">

reviews

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Connecting Our World: GIS Web Services
By Winnie Tang and Jan Selwood.
Redlands: ESRI Press, 2003.
164 pages, numerous color illustrations.
Soft cover, 7.5 by 9 inch format.
ISBN 1-58948-075-9

Reviewed by David Broscoe,
GIS Technology Programs,
Algonquin College
Ottawa

This volume continues ESRI Press tradition of publishing well-produced, relatively inexpensive books on various facets of GIS. Most of the press's other books have focused on a given application area (GIS and Business, GIS and Emergency Services, GIS and …). *Connecting Our World*, narrowly targeted at managers, describes how web technology can be used in a number of different application areas by a range of organizations to serve GIS data to the web. The narrow target audience limits its appeal to others in the field, and narrowly determines the range of material covered in the book. I will first summarize the book content and then undertake an overall critique.

The introductory chapter discusses the concept of WebGIS, outlines some of the potential advantages to an organization in using a WebGIS approach, and very generally discusses the required technology and the de facto standards that have been developed.

Each one of the next twelve chapters outlines one particular application of WebGIS. The first chapter discusses the Geography Network, a 'metadata search-and-discovery framework that

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permits exploration of distributed spatial data sets and services' (p 11), launched by ESRI in 2000. The chapter describes the use of Geography Network architecture to implement specific gateways (Kentucky's Geography Network, Delaware's Data Mapping and Integration Laboratory and the United Nations Environment Network). In each case the software (inevitably including at least one ESRI product) and hardware implementation is described. The (mostly) implicit tie between the book and ESRI products and services will be discussed later.

Chapter two examines a national implementation, New Zealand's TopoOnline, which provides users with web access to a full range of online topo map series. One generic technical issue explained in some detail is the conversion from a local geodetic datum to a geocentric geodetic datum compatible with WGS84 and therefore with GPS.

While many large organizations choose to implement and maintain their own web servers, many smaller organizations elect to contract out these services. Chapter three describes three such implementations, one involving the Crown Estate, the agency responsible for managing the estates of the British Crown, and two involving local government applications.

While the geographic data in the implementations discussed in previous chapters may be browsed by anyone with a web connection and a browser, many enterprise-wide WebGIS implementations are designed to limit access to those who work within an organization. The 'Native Title View' of the LandLinks service of the Department of Land Administration, Western Australia, is one such application described in chapter four.

Three approaches to property management are described in

chapters five, six and twelve. Chapter five describes the National Land Information Service (NLIS), a joint initiative of UK national and local governments. The NLIS is a subscription-based service whose aim is to "speed up delivery of publicly held land and property information used in land searches" (p 74). The service is designed to facilitate information transfer between lawyers and information services such as water authorities, cable companies and local authorities. This e-commerce application incorporates a means of distributing fees for services to appropriate organizations depending on the information provided.

Chapter six describes a commercial real estate application in the Southeast Asian market. The application allows a private organization to manage and serve current real estate information about a volatile property market over a wide geographic area. Chapter twelve discusses an American service providing real estate information to potential homebuyers.

Chapters seven and eight describe real-time tracking applications, with or without the use of GPS, as 'even without GPS, the location of a mobile phone user can be pinpointed to within fifty meters' (p 97). Chapter seven outlines the Icelandic company Trackwell's initial application to monitor the location of seagoing vessels in conjunction with the Icelandic Life Saving Association. The author only hints at the ramifications of this surveillance technology:

…it quickly became clear that this technology could be expanded to help monitor and manage all fishing activity around Iceland. … For [fisheries] organizations, monitoring the location and status of fishing vessels would help surveillance and enforcement of agreements (p 99)

Chapter eight investigates the intersection of Location Based Services (LBS) and Web GIS. 'A user with no more than a mobile phone or a PDA could receive information of help that was specifically targeted based on their current location' (p 113). In order for this technology to work

the location fix calculated by the mobile operator [has] to be passed to some form of GIS … that [can] compare the fix against spatial data sets, such as address, point-of-interest, or route networks, and then implement spatial operations such as geocoding, proximity searches, and shortest path routing (p 113)

The author discusses in some detail various approaches to and standards for mobile positioning, along with the implications of decoupling the locational technology and the technology involved in implementing other aspects of mobile phone service.

MapShop, a subscription-based mapping web service provided by the Associated Press, is described in chapter nine. This is one of the few chapters with explicit discussion of cartography, with an example of a shaded relief map as served by the Internet, intended for use in daily newspapers

Chapter ten highlights how WebGIS has been used in education to teach water management and conservancy along with GIS concepts in the North China Institute of Water Conservation and Hydroelectric Power. The chapter focuses on the ability of WebGIS to emulate standalone GIS functionality with respect to building and editing spatial data sets.

Chapter eleven discusses the use of WebGIS in the Oil and Gas industry. Up to date information about all major oil producing areas is provided to subscribers using browser technology. This is a more timely approach than the previous approach of distributed CDs and standalone GIS or other

data browsers.

My major issue with this book is its narrow focus. According to the back-jacket description, the book is 'an essential guide for forward-thinking managers who are interested in levering the power of spatial data and information'. One would imagine that savvy managers might already be aware of the technology, and would continue to learn about the web primarily from the web. Where the book has real value is in the specific technical information about the implementation of the applications not directly available from the sites.

The book is unlikely to appeal to academics for several reasons. First, it adopts an uncritical, unproblematic approach to technological innovation viewed as implicitly 'beneficial' or at worst neutral. Several chapters in particular could have benefited from a more critical viewpoint. The debate about privacy versus convenience with Location-Based Services technology is now mainstream enough to be reported regularly in the newspapers. Who has the right to know the exact whereabouts of an individual at any point in time? At what point does efficiency and convenience become an invasion of privacy? This issue is contentious and deserves acknowledgement.

The Australian 'Land Title View' application described in chapter three is accessible only to a select group of people, who have the ability to view an integrated set of data layers. One could question what decisions are made based in that information and whether Aboriginal Australians have equal access to that information. *Ground Truth* by Pickles, *Digital Places* by Curry and the research stemming from the NCGIA Initiative 19 are suggested as alternate visions, although they may not deal with WebGIS specifically.

Second, visualization and representation issues are barely addressed. To give a simple example, the Web poses a number of specific hurdles to 'optimal' representation, not the least being the heterogeneity of browsers and platforms that map viewers may be using. In that situation, how do you insure that what a given user sees optimally represents the data? No doubt the authors could argue that these issues were not within the mandate of the book, but Peterson's *Maps and the Internet* strikes me as a model for a more interesting approach to the subject.

If the book does not offer a critical approach, neither does it function as a technical manual. There is just enough information for someone not familiar with the technology to know that there is a lot to know. One could decide to do research on any number of acronyms that may be encountered in the text, but there is not nearly enough information to attempt an actual implementation. The book does give a sense of the hardware and software configurations for most of the implementations, but not of the amount of time and energy involved in creating the applications. In addition, WebGIS is a volatile technology. Very likely the descriptions of some of the technical specs were out of date at the publication date and are more outdated now. Of course, this is a common issue for all books that discuss the technical implementation of a rapidly developing technology.

A last observation, an issue that is common to most ESRI Press books is the fact that all the described applications involve ESRI software in one way or another. Neither the approaches of other commercial vendors nor the battle between Open Source and proprietary software are mentioned.

Overall the, book is well produced and reasonably well written, but targeted to a very narrow audience, the manager. It introduces a sufficient range of WebGIS applications to give the reader a sense of the field. It gives a technical overview of each application, so that a manager could make a rough estimate of implementation costs. Concise explanations of relevant geographic concepts are interspersed throughout. The book could conceivably convince a manager that their organization could benefit from WebGIS. For academics, however, there is insufficient critical analysis or discussion of visualization. For technical people, there is only sketchy technical information. There is little in *Connecting Our World* to appeal to the NACIS audience.

A Railroad Atlas of the United States in 1946: Volume 1: The Mid-Atlantic States.
Richard C. Carpenter. The John Hopkins University Press, Baltimore, MD. 2003. 297 pages, numerous maps, hardcover (ISBN 0-8018-7331-2).

Reviewed by Fritz C. Kessler, Frostburg State University.

This atlas presents a unique perspective on the state of railroading in the United States during 1946, when railroads were the dominant form of travel and commercial transportation. In a dense hardbound volume, 177 color maps covering the Mid-Atlantic States illustrate, among other items, the location of each railroad's line, the towns through which the line passed, mile posts, signal towers, coaling stations, and passenger stations during 1946. The considerable amount of information presented throughout this atlas makes it possible for anyone with an interest in railroad history to gain an appreciation for the enormous and complex network of rail lines that at one time wove their way across the Mid-Atlantic States.

The atlas is divided into five sections. The first presents a brief history of railroading in the United States, the author's justification and enthusiasm for undertaking such a work, as well as a synopsis of each Mid-Atlantic State's (PA, WV, DC, MD, DE, NJ, and VA) railroad composition in 1946. Carpenter explains that his reasons for producing this atlas stem from three points. First, this atlas serves to graphically document "one of the most glorious episodes of our transportation history" (p. viii). Beginning in 1950, the 137 Class I operating railroads in the United States would, by 2001, merge into seven Class I railroads. Second, Carpenter notes that some of the oldest railroad lines in the United States originated in the Mid-Atlantic States region. Third, Carpenter, recalling fondly his own memories of railroading in 1946, seems nostalgic in his description of life and scenes along the railroad and paints an idyllic setting for the atlas' content. Unfortunately, Carpenter is not clear on who his intended audience is or where his atlas fits within the numerous railroading atlases that are in publication.

The second section of the atlas begins with an index map that aids in locating individual atlas maps. The index map is followed by an explanation of symbols, and then the 177 maps are presented. As indicated by Carpenter, the USGS 1:250,000 map series of this region was utilized to compile the atlas' base information. All atlas maps are produced in color, are entirely hand-drawn (including all text), and contain the same base information: shorelines, rivers (with flow direction indicated), canals, towns along rail lines, and boundaries (national, state/provincial, county, and city). The amount of base information included is pur-

posefully kept scare to reduce each map's complexity, allowing for the important railroad information to emerge. In compiling the base information, it appears as though Carpenter took a series of colored markers and traced the relevant information directly from the various base map sources. Individual railroads that were in service and abandoned in 1946 are identified by one of nine colors. Carpenter states that the colors to illustrate each rail line were chosen according to any historical association to a particular railroad logo. For example, the color chosen to illustrate the Baltimore & Ohio railroad was blue (the color scheme of the B&O was royal blue and grey). The corresponding railroad name is shown in black text attached to the rail line. Symbols for passenger and non-passenger stations located along each line are shown in the same color as the owning railroad. Mile post values, names for tunnels, viaducts, coaling stations, and track pans are shown in black text. Names of interlocking towers are shown in purple text. The adjoining map numbers are listed in the margins of each page facilitating the location of adjacent maps in the atlas.

Each map covers 30 minutes of longitude and latitude (values are shown at each map corner), which facilitates comparing the atlas maps not only to the original 1:250,000 series but also to other widely published maps. Where appropriate, tic marks for 15 minute divisions are included inside each map. The atlas maps are presented at an approximate scale of 1:270,000. Each atlas map is named according to a prominent railroad station found on each map. This naming convention permits the map user to quickly find a specific atlas map on the index map. The maps are arranged from west to east and from north to south and are also numbered sequentially in this fashion. Thus, the first map in

the atlas is Erie, PA while the last map (numbered 177) is Norfolk, VA. In several instances, more detailed coverage of congested railroad networks, usually around metropolitan areas, are included as separate maps. For instance, Pittsburgh, PA (map 57) is mapped at the normal 30 degrees of latitude and longitude, but a more detailed map of the greater Pittsburgh region (map 57A) is shown covering 7.5 minutes of latitude and longitude and at a reduced scale (a scale bar is included on each detailed map). Note, however, that this same 7.5 minutes of latitude and longitude extent is not universally applied to the more detailed maps found throughout the atlas.

The third section is an appendix, which presents an alphabetized inventory of the abbreviated railroad names (e.g., B&O) used in the atlas. A quick perusal of the appendix reveals common railroad abbreviations such as the C&O (Chesapeake and Ohio Railway), PRR (Pennsylvania Railroad), and N&W (Norfolk & Western Railway). However, lesser important railroads are also listed such as the W&OD (Washington & Old Dominion Railway) and IRN (Ironton Railroad). Thus, the appendix is useful in identifying the railroad abbreviations and subsequent railroad lines that are illustrated throughout the atlas.

The fourth section details interesting notes with respect to the various maps and the rail lines found within as well as a list of references used in compiling the atlas. I found myself spending considerable time reading through the notes section learning fascinating railroad lore. One such intriguing note, for example, indicates that along the B&O line that ran through Cairo WV, "there were no fewer than 14 tunnels in 35 miles (p. 216)" while another note signals the "Big Bend" tunnel, near Hinton, WV as the setting for the popular folk ballad "John Henry"

(p. 219). The notes section helps us see how railroads have contributed much to the geography, history, and culture of the United States.

The fifth section includes a very lengthy index containing six separate alphabetized lists detailing the location of coaling stations, interlocking stations, passenger and non-passenger stations, track pans, tunnels, and viaducts. Coaling stations were necessary on some railroad lines to re-supply steam locomotives with coal. Interlocking stations, or signal towers, were relied upon to maintain control of the daily operations of railroad traffic. Track pans were ingenious devices that were designed to re-supply steam locomotives with water without actually having to stop the train. Names of coaling stations, interlocking stations (and their one or two-letter abbreviation), track pans, tunnels, and viaducts are listed along with the owning railroad, the state in which each feature was located, and the atlas page on which each feature can be found. Passenger and non-passenger stations are listed in a slightly different format and include only the station name, state, and atlas page on which these stations can be located.

It is apparent that Mr. Carpenter has put forth a tremendous effort in creating this atlas. The amount of time that it must have taken him to trace the linework and print all the text is beyond my comprehension. Having said that, I am bothered by the lack of cartographic excellence I expect from an atlas.

In many cases, the color marker approach taken in this atlas does not come across well. In all cases, the ink flow is noticeably inconsistent, and because of this, on some maps it is difficult to distinguish each railroad line. For example, the map of Westfield, NY (map 2) shows the New York Central line running along the shores of

Lake Erie in a light brown. But due to the uneven ink flow, the line fades in and out and at times almost disappears (you can even tell where Carpenter stopped and started tracing most line segments). In a similar light, the map of Scranton, PA (map 35) uses an orange ink to highlight the rail lines of Lehigh Valley. Again, due to the inconsistency of ink flow, the orange line becomes washed out and faded and in the more congested areas on the map it becomes difficult to distinguish the Lehigh Valley line from the Delaware and Hudson line (shown in brown) and the Pennsylvania Railroad line (shown in red). The poorly drawn linework carries over into other linear features. For instance, on the map of Newark, NJ, (map 53) some of the county boundary lines are smudged, vary in their thickness, and the dashes are not of the same length. In the inset map of Newark, NJ (map 53A), the Lehigh Valley line running parallel to the Pennsylvania Railroad on the far right side of the page simply fades away.

The maps also demonstrate examples of inconsistently produced linework. For, instance, the shorelines representing Newark Bay shown on the Newark, NJ map (map 53) have gaps along some stretches and are erratically drawn. In another part of this same map, there are errant blue lines drawn on the left side of the page. Inconsistent linework is also found on the Philadelphia, PA map (map 82A). Examining map 82A, one is struck by the variations in line thickness for the rail lines. As an example, sections of the Pennsylvania Railroad are drawn using a thinner line. I assume that the thinner linework represents sidings or rail yards, but I am uncertain as to my assertion. Unfortunately, examining the explanation of map symbol page, one finds no clues as to the significance of variation in

this linework. In short, the hand drawn execution of maps in this atlas is poorly rendered.

Another significant problem is the fact that the maps show no variation in text variables such as serif/sans serif, type face, type family, etc. While variation in type size and a mix of upper and lower case letters is present on the maps, their execution is inconsistent and poorly presented. A casual overview of the atlas maps reveals violations of cartographic text placement 'rules'. Several of the violations include text being positioned on a slant and resting along an inconsistent baseline. On many maps, especially those covering denser portions of the Mid-Atlantic States, text overlaps linework making readability a challenge. Other maps display text that is smudged, has inconsistent stroke thickness, poorly hand-printed, or too small to be seen.

The map design concept is very simple, in fact too simple. Examining the maps one is struck by the absence of figure-ground. For instance, on maps where a thin light blue stroke delineates shorelines, water bodies have no fill color applied to contrast with the landmasses (which also have no fill). Because of this basic design flaw, the map reader will have difficulty not only differentiating between land and water and but also in orienting the map with the local environment unless they are familiar with the mapped area. I will note that Carpenter did try to create some contrast with the linework. Active rail lines are shown with a solid stroke while abandoned lines are represented with a dashed line. As mentioned earlier, each rail line is represented with one of nine colors. However, on some maps where there are several rail lines (e.g., map number 53, Newark, NJ), identical colors are used for more than one railroad, which can cause confu-

sion unless the reader carefully inspects the text identifying each rail line's owner. Other linework on the map does exhibit some contrast. Lines delineating various boundaries are shown using a thin black stroke with varying forms of dashes (e.g., state boundaries use a long – short dash while city limits incorporate only short dashes) and water features are illustrated with a light blue stroke having the same thickness as the boundaries. Thus, while there are attempts to create visual contrast with linear features, maps that are particularly complex ultimately confuse the map reader as they try to mentally categorize the different linear features.
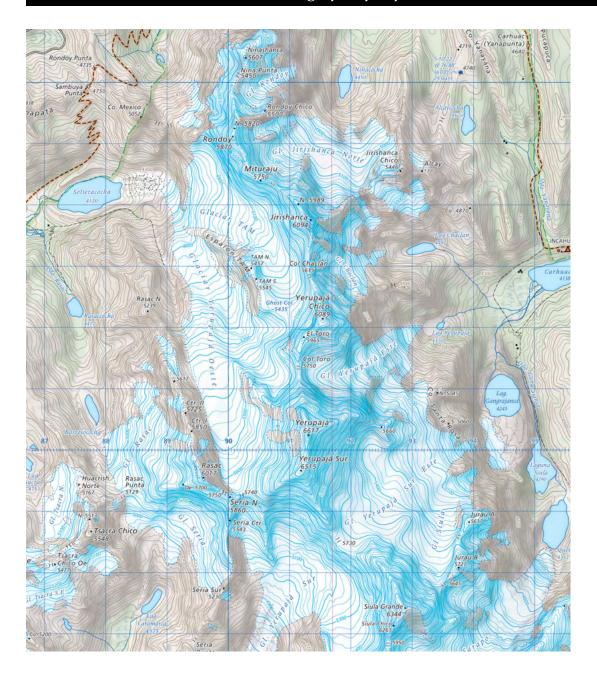
While the sheer volume of text and maps included in this atlas is impressive, Carpenter's manual approach is a major shortcoming. I hope that future volumes would be prepared in a digital environment, which would open up many opportunities to improve upon cartographic design. Enhancing figure-ground and visual contrast would be foremost in my suggestions on areas to improve. The digital environment would also provide opportunities to manipulate text variables that would enhance the overall readability of the atlas. As an additional suggestion, shaded relief would be welcomed and a very appropriate addition to this atlas. As the atlas stands, unless the reader is familiar with the local landscape of a specific area, there is no evidence to suggest why the rail lines bend and curve as they do. Through the addition of shaded relief, the tie between geography of the landscape and positioning of the rail lines would be immediate.

In spite of these cartographic limitations, I can recommend the atlas to anyone with an interest in the greatest railroading era in the history of the United States as the text is a valuable reference tool. Specifically, I can envision

railroad historians relying upon the atlas to provide a condensed reference for visualizing the rail network as it existed in 1946 or researching individual railroads as they existed during this time period. On the other hand, coupled with a modern map of a specific region in the Mid-Atlantic States, rail-fans would enjoy tracing where their favorite railroad line traveled. Even model railroaders, who might want to model a section of their favorite railroad line as it existed during 1946, would benefit perusing this atlas. However, cartographers seeking well designed maps in a railroad atlas would be advised to look elsewhere.

visual fields

Cordillera Huayhuash, 1:50,000   59
Designed by
Martin Gamache
Alpine Mapping Guild
alpinemappingguild@earthlink.net

Cordillera Huayhuash, 1:50,000
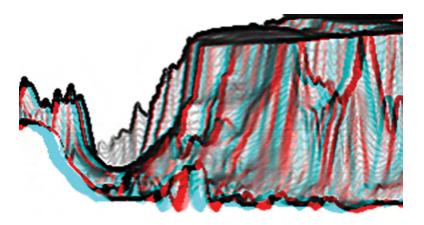
In 2002 we published the first incarnation of our Cordillera Huayhuash map at a scale of 1:65,000. Our initial data sources were Peruvian IGN 1:100,000 topographic maps and Landsat TM imagery. Although the map was well received by the user community, it was clear our dataset was not adequate for our goals. In the ensuing years we successfully obtained more recent 1:25,000 digital data from the Peruvian land tenure reform agency PETT. We compiled a new base map at a scale of 1:50,000 and generated a fairly detailed 25 meter DEM. 15m resolution ASTER satellite imagery from 2002 and 2003, and 1999 Landsat ETM+ was also obtained. The imagery was orthorectified using the DEM, mosaiced and classified to obtain landcover information and to delineate glaciated terrain. We used several image processing methods to create an aesthetically pleasing background image incorporating shaded relief, terrain texture, trails and protected area boundaries. This image was created as CMY TIFF. Additional vector line work overprinted the image in black, cyan and two spot colors. Extensive fieldwork, user and local expert interviews were conducted during the 2002, 2003, and 2004 Peruvian trekking seasons. The new map was printed in Lima in August 2004. Inspiration for this map was found in the cartographic work of the Swiss Foundation for Alpine Research, the expedition maps of the German and Austrian Alpine Clubs, and the hiking maps of Pat Dunlavey.
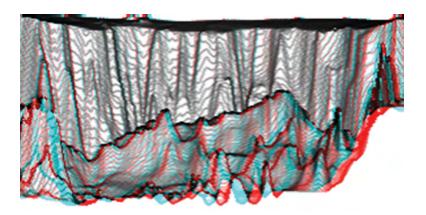
For more information contact: Martin Gamache/Alpine Mapping Guild (alpinemappingguild@earthlink.net)

color figures

a. Subset looking north through the opening into Condor Chasma.

b. Subset looking at the south wall of Mellas Chasma.

Figure 12. Subsets of the Valles Marineris 1/64° x 1/64° DEM centered on the arrows shown in Figure 10 were converted to DDMs and induced with parallax before creating the left and right perspective slope images in the form of anaglyphs displayed above. Red-cyan glasses with red over the right eye are needed to view these images.
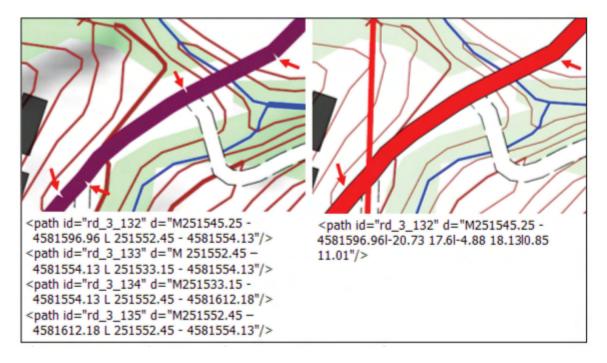
Figure 1. Inappropriate topological structure of DLG objects – unneeded number of vertices and breaks (on the left) instead of one solid line (on the right) – that have impact on the graphical representation and amount of SVG code.
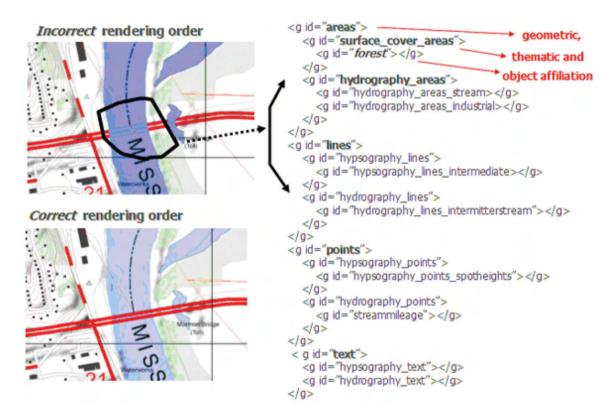

Figure 3. Example of the "overlap problem" caused by an incorrect hierarchical rendering object order with the proposed correct SVG code structure.
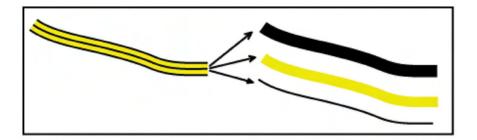
Figure 4. Multi-line composed of three styles as proposed by Neumann and Isakowski (2002).
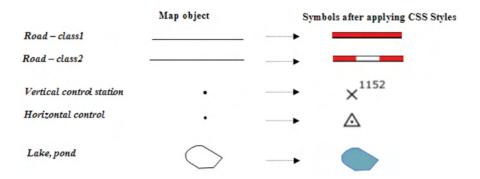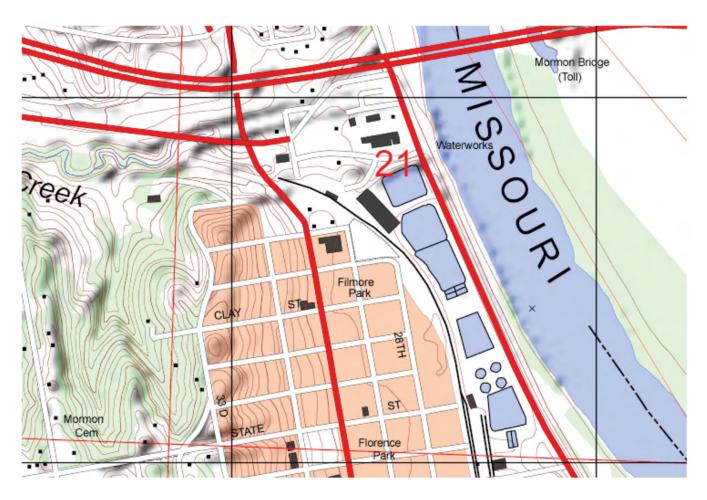

Figure 5. Applying styles using CSS to create map symbology.

Figure 6. SVG provides considerable quality of graphics (detail associated with SVG).
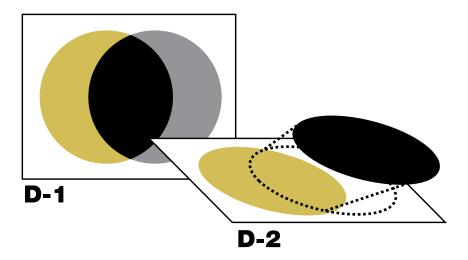

D-1

D-2

Figure 1. Note that the yellow circle isn't really a circle underneath it all.