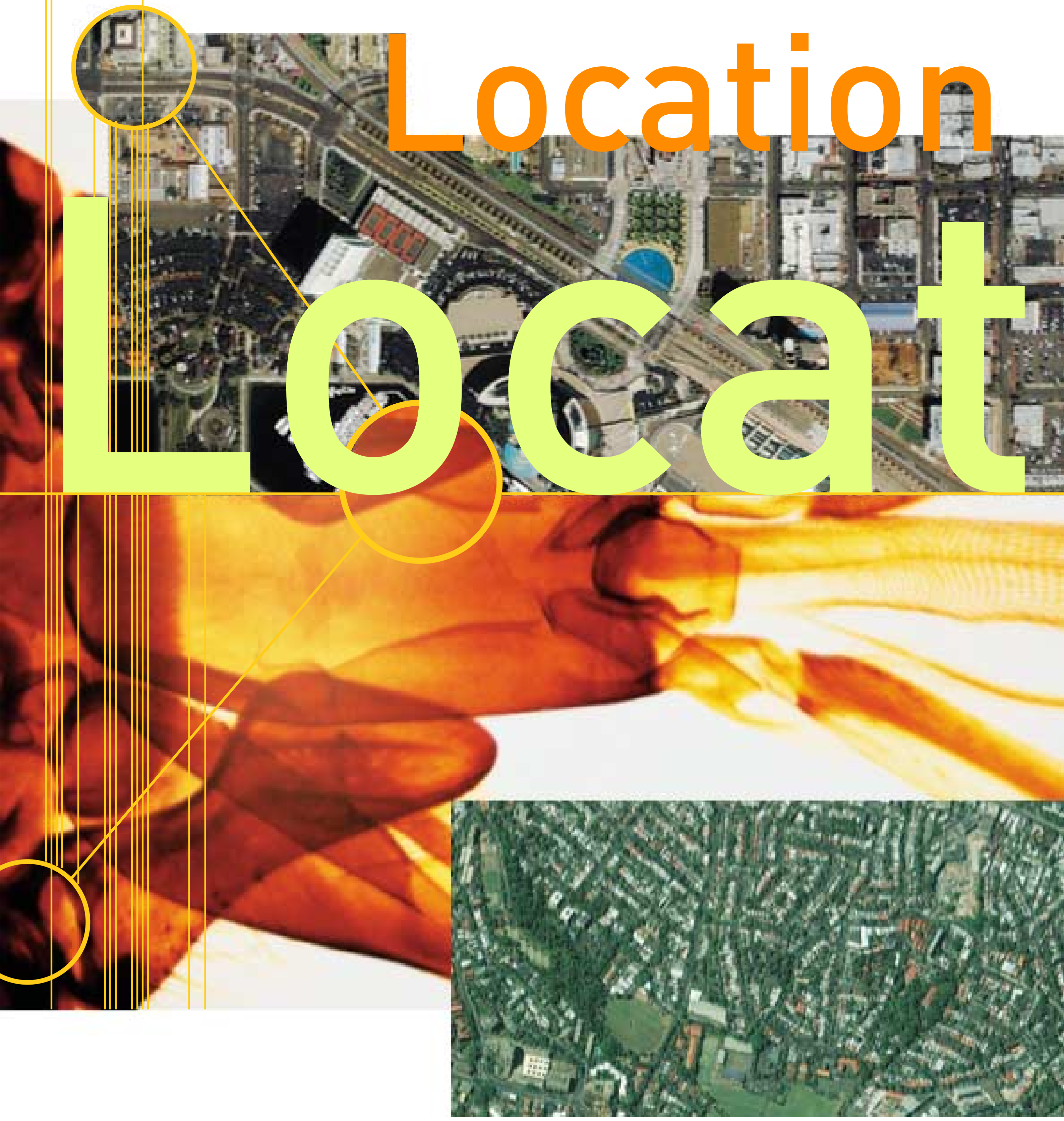
Location



Location
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With new technologies, online maps can show us the world more clearly than ever.

By Brian and Jeffrey Ambroziak

www.spaceimaging.com

An early morning chill in the South Dakota hills. Fossil hunters feel their way along the cliffs in search of dinosaur remains.The crew huddles as one member pulls a dusty geologic map from a backpack and carefully spreads the creased paper across a boulder. But little attention is paid to it, as the modern-day treasure hunters watch a laptop booting up. In fact, the map, a relic from bygone days, contributes its last utility—as a dust protector for the computer, which is now wirelessly connecting to detailed, full-color satellite data of the surrounding cliffs and to a digital elevation model (DEM) from the U.S. Geological Survey Web site.

The scenario may sound far-fetched, but it isn't; it's feasible today. The power of the Internet, combined with the huge amount of digital geospatial data now available, is heralding a revolution in mapping—a heretofore unimagined leap in our ability to visualize the world around us.

While the full commercial availability of advanced mapping technologies—such as SVG, broadband connections, 3-D renderings, and high-resolution monitors—rests just beyond the horizon,

Vacations and nations

Good maps are soothing. When we're lost, they tell us how to get from here to there in the shortest possible time, so we can still find that museum and make the flight home. And they also provide us with the comfort of knowing what's around us, or what's beyond that hill. They banish the unknown.

But the nature of maps gives rise to a lot of impatience, too. And that's one of the biggest problems for online maps—how to make them useful with plenty of detail while not forcing readers to wait too long for large files to download. MapQuest, one of the leaders in online map services, is now working to make many of its print-based maps, all created in Adobe Illustrator, available for the Web. The solution is SVG—a format that keeps the maps relatively small, but that can provide great amounts of detail with vector graphics. And SVG promises to add smooth and quick interactivity, such as zooming and scrolling, to future online maps.

The comfort of good maps, however, isn't just for the vacationer. MapQuest's litigation services are helping calm more high-profile kinds of customers—nations involved in boundary disputes. Giving multimedia presentations at the International Court of Justice in The Hague in the Netherlands, MapQuest tries to show who has the right to do what. "Many of these cases are land-based," says Scott Sandall, Director of Business Development at MapQuest, "but more and more are maritime-based, for economic reasons. Oil, petroleum, mineral rights . . . does one country actually have the sovereign right to lease an area to a private company for exploration? It's a very large and growing area."

The locations in Washington, D.C. (left and right) are from a map in SVG format, developed by MapQuest (included on the Adobe Illustrator 9 CD). In addition to allowing smooth zooming and text searches, an online SVG map can let you turn various types of information on or off, using underlying layers. One layer, for example, could show all the roads, while another could show bus lines or highlight recommended restaurants. Customers such as newspapers, hotels, or municipalities could also purchase individual layers from map developers for specific uses.

glimpses of these transforming solutions are already available to Web surfers. Perhaps most familiar are the Web maps from MapQuest. Incorporated into myriad search engines and third-party Web pages, MapQuest's technology enables the dynamic creation and viewing of any address in the U.S., Mexico, or Canada, taking the guesswork and frustration out of the family road trip. MapQuest even provides detailed written directions from any North American location to another, and is planning to provide such services for the entire world.

DeLorme's Topo USA software, used with a global positioning system (GPS) receiver, provides real-time topographic imagery of the viewer's location via laptop. For the seafaring, Maptech offers a range of software packages that provide detailed renderings of the ocean bottom, combining contour and positioning information. A weekend boater can now navigate the most treacherous shorelines guided by images on a laptop.

A cartographic history

Such advances in data-gathering and mapping reflect our age-old need to know what is beyond our single vantage point. The ancient history of mapping is a fascinating story of humans' innate ability to conceptualize the relationships among various observations, to create a language of suitable abstractions to express this knowledge, and to record the language in tangible form.

The vast connections of the Web are providing access to once-hidden geographic data.

Such conceptualizing is nowhere more apparent than in the Marshall Islanders' "primitive" navigational charts; to make them, the islanders used shells to represent the scattered islands of the Pacific, and attached the shells to intersections of palm fibers tied together by threads from coconuts. These threads indicated the pattern of wave masses caused by winds and the directions from which waves approached the islands. By spreading these maps on the decks of their boats and keeping constant the angle formed by the boat and the direction of the prevailing waves, the islanders could navigate across huge expanses of featureless ocean.

The display of geospatial information improved, of course, with the introduction of printing. Copperplate engraving and lithography led to detailed and artistic representations that included hachures and contours.

Maps from space

Don't look up now, but you're on Candid Camera—of the outer-space variety, anyway. Companies such as SpaceImaging, EarthWatch, and ORBIMAGE have lofted cameras into space on the backs of orbiting satellites, which are, as you read this, capturing high-resolution imagery of the entire earth. Though the satellites' one-meter resolution cannot actually identify individual people, it can let you distinguish easily recognizable objects such as buildings, swimming pools, roads, cars and trucks, and even the white stripes in crosswalks.

Such detailed imagery can provide cartographers with extremely accurate digital elevation models (DEMs), which they can use to display steepness, slope direction, and contours in topographic maps. Digital maps of the future might combine the symbols of roadways and landscapes with satellite imagery, giving you up-to-date views of construction, for example, or flooding.

And the ease of finding such images on the Web is remarkable. Brian Soliday, vice president of SpaceImaging's North American sales and marketing, notes that "technology for delivery of imagery via the Internet is advancing rapidly. Although the tools exist for the power user, you don't have to be a GIS or mapping expert to find an image from space. All that's needed is a basic understanding of geography or the name of a nearby landmark." Indeed, on SpaceImaging's Web site (www.spaceimaging.com), you'll eventually be able to type in an address and date range to bring up an aerial color photograph, which you can then purchase. In the meantime, you can go to the TerraServer site at www.terraserver.microsoft.com to take an alien's view of Area 51, or find, by taking a "balloon ride" over your old town, the rooftop of your childhood home.

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Bird's-eye view

In addition to helping us find the fastest and safest route between locations, maps can show us how certain things are distributed over the surface of the earth, such as pollution or political leanings—any kind of information that you can count, track, or analyze statistically. Researchers at Cornell University's Department of Ornithology are counting and mapping birds, using the Web to collect and present the data.

In a project called The Great Backyard Bird Count (GBBC), thousands of volunteers—amateurs and experts alike, from all over North America—record the number and species of birds they see in their backyards over four days in February and report them to the GBBC Web site (birdsource.cornell.edu/gbbc). Reports are checked for accuracy (a sighting of ten robins in the Yukon would be suspect, for example) and collected in a database. The data is run through ESRI's ArcView software to create what's called an "abundance map," which uses different shades of green to show populations of each reported species (right). This year, GBBC received over 62,000 Web entries, reporting sightings of 419 different species.

Roger Slophower, a geographic scientist at Cornell who helps direct the bird-counting project, is delighted with the response."What's really interesting," he says, "is to count the number of hits on the site, multiple millions of them. People want to come back, each hour sometimes, to see what's been reported. We're looking at a real participatory science project." And Slophower says that the maps help encourage the public to get involved in protecting birds in certain regions. "They can learn [from the maps] not only where the birds are, but why the birds are where they are. For conservation purposes, that's really the ultimate question."

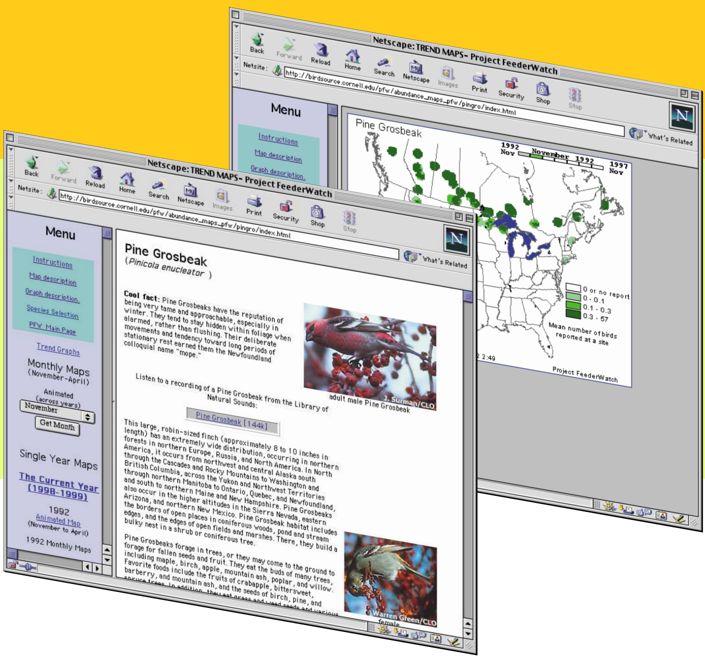
But while there was a steady improvement in map display over the years, collecting the underlying data still required the unchanging, firsthand observations of explorers. One hundred years ago, François Matthes mapped the Grand Canyon by feeling his way along the mighty Colorado River on foot and by mule, recording observations on a drawing board mounted on a tripod. There were further advances with aerial photography; in 1930, Army captain Albert W. Stevens rode a balloon to a high altitude over the Black Hills of South Dakota and took the first photograph evincing the gently curving nature of Earth.

The ability to analyze geographic data was greatly improved with the introduction of powerful computers and the Geographical Information System (GIS), a combination of hardware, software algorithms, and geospatial databases. The promise such systems held for mapmaking was great: they would dynamically combine layer upon rasterized layer of related geospatial information to create digital maps that, unlike traditional maps, could be changed in an instant. They could, for example, selectively display data on rainfall or temperature.

The problem was that such analysis was restricted to the computers that could handle it—typically, mainframes that cost tens of thousands of dollars, required years to master, were virtually impossible to use with externally generated data, and couldn't output results in a manner easily readable by any other product. And advanced aerial photography from satellites was, for the most part, the property of spy agencies, not available to civilian cartographers.

GIS, XML, SVG, you're there

But affordable GIS software and image-editing tools that let you manipulate geographic images are starting to change all that. The vast connections of the Web, too, are now providing instant access to long-archived or newly



created geospatial data. And with the end of the Cold War, once-secret satellite imagery has become available to mapmakers and the general public.

Take, for instance, The TerraServer project, a test project sponsored by Microsoft (see "Maps from Space," page 39); it has mapped many parts of the world with images from both Russian and U.S. satellites. You can type the name of your city, for example, then zoom in to find the roof of your house. Other companies, notably Space-Imaging, EarthWatch, and ORBIMAGE, have launched their own commercial satellites to take detailed photos of the entire planet. Although in the future the creation of online maps may rely heavily on such photography, the photographs typically contain too much detail to be useful as maps themselves. We still need the abstract symbols of roads, rivers, and train lines to keep views simple and easily understood.

For online use, combining and editing seemingly related map data gives rise to a host of complexities. Cartographers often want to combine layers from different maps to form different views of the same region, but the maps may vary in scale, resolution, and projection. A color-coded map, for example, might be mixed in with a satellite image of the same area. How does one easily combine two maps, each of which is in a separate map projection, and composed of pixels that differ in their placement depending upon the projection?

The problems of scale are particularly troublesome when you're dealing with raster data. When raster data is enlarged beyond its maximum resolution, pixelation occurs; and scaling raster images to non-integer values requires computationally intensive smoothing to filter out unsightly effects. Moreover, raster images often require large file sizes not ideal for Web use.

One solution to all of these problems rests in the recently created scalable vector graphics format, known as SVG. SVG is a two-dimensional graphics standard structured in extensible markup language (XML) that allows graphic elements to act as adaptive and interactive data elements. In addition, SVG offers a host of aesthetically pleasing animation features, including style properties such as gradients, opacity, fill color, and line width. Along with its compression attributes (vector graphics are always smaller than raster images), SVG offers much promise as the format of choice for geospatial data. You could, potentially, zoom in and out of an SVG map without waiting for the screen to refresh, seeing as much detail as you wanted, even down to individual buildings on a street (and perhaps the floor plans inside them). See *www.adobe.com/svg* for more information.

One day, you might be able to roll up your digital map in your backpack.

Mapping the future

As GIS software becomes as commonplace as word processors, everyone will be able to zoom in from outer space to see their back-porch barbecues. GIS platforms linked to sources of geospatial data through high-bandwidth connections will open a new window to our world. Next year, a company called A3Dt will introduce software that will make it possible to combine satellite and map imagery in any projection and scale, with any format of digital data.

And new information about our planet is being gathered every day. High-resolution, digital elevation data of eighty percent of the earth's surface, collected recently by the Space Shuttle, is being processed for delivery to the public early next year. By combining point, line, and area data with new elevation and imagery information, everyone from petroleum engineers to town planners will be able to explore their regions in incredible detail. Why wonder what the view looks like from the rim of Mount St. Helens when you can create it from anywhere on the mountain without leaving your laptop?

One day, you might even be able to roll up your digital map in your backpack. With the recent development of "electronic ink" and the ability to turn a seemingly ordinary page into a graphic display, you could be spreading that creased map on a boulder while you download information into it from the Web. In the future, we'll all know exactly where we are, wherever we happen to be. ◗

Brothers Brian and Jeffrey Ambroziak are co-authors of Infinite Perspectives: Two Thousand Years of Three-Dimensional Mapmaking *(Princeton Architectural Press), a book about the history and technology of topographical representation.*