Webcams, Interactive Index Maps, and Our Brave New World's Brave New Globe

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Intermittent video supplied by a webcam affords near-real-time images that can approximate the dynamic scenes of full-motion video. As map supplements, webcam images offer readily interpreted on-the-spot reports of traffic flow, crowdedness, cloudiness, scenic beauty (or ugliness), and other directly observable aspects of the physical and human landscapes. And as easily interpreted cartographic point symbols, webcam images offer a range of visual variables, including size, numerousness, texture, rate of change, and value. Readily integrated with the maps, photographs, other images and the narrative text of electronic atlases and atlas-like websites, webcam images depend upon maps in two ways: locator maps provide the spatial context without which many webcam images have little meaning, and index maps help viewers identify places for which webcam images are available. As a medium for monitoring landscapes and watching people—with or without the subject's awareness and acquiescence—the webcam is symptomatic of electronic cartography's newfound capacity as a technology of surveillance.

INTRODUCTION

Among the defining characteristics of multimedia cartography is the integration of maps with text, statistical graphs, diagrams, photographs, and sound. Although all five categories of non-cartographic media can promote understanding of a map's symbols or patterns, photographs of familiar or easily interpretable features afford the most efficient link between a real landscape and its cartographic representation. A staple of printed world and regional atlases designed for general audiences, complementary photographs are abundantly apparent in electronic atlases, in which still photos and video clips often consume the bulk of CD-ROM memory. Emergence of the Internet as the primary mode of multimedia mapping has accorded photographic imagery an even greater presence through the webcam, which affords a ground-level perspective of traffic, weather, or tourist attractions, as well as sustained, real-time monitoring of public space here or abroad. This paper examines the operation, limitations, brief history, and cartographic role of the webcam, and argues that these video viewports are symptomatic of electronic cartography's newfound capacity as a technology of surveillance.

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WEBCAMS AND CARTOGRAPHY

In its simplest and most common implementation, a webcam is an image file—let's call it *ourcam.jpg*—stored on a webpage and displayed on the viewer's computer by a line of HTML code that looks like

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Page layout instructions tell the viewer's computer where to place the picture on the screen, and the webpage's server refreshes the image by downloading the file's current contents at a fixed interval, which might be as short as a fraction of a second or as long as an hour. The picture changes as the image file is refreshed with a new scene recorded by a digital camera, captured by a video card and converted to a GIF or JPEG image, which is fed to the host server (Nemzow 1998, 26-46). Setups vary widely, and few webcams approach the Internet TV standard of full-motion video (Kotis, Lambert and McGregor 1999). Although some webcam sites offer a more or less continuous stream of live but jerky video images, others require the user to update the image manually, by clicking on a command phrase or the picture itself. Image quality varies less markedly, with the typical webcam presenting landscape-oriented color snapshots comparable in resolution and screen size to a QuickTime or RealPlayer viewport.

"The picture changes as the image file is refreshed with a new scene recorded by a digital camera . . ."

Web lore recognizes Cambridge, England, as the webcam's birthplace. In 1991, scientists at the Cambridge University Computer Laboratory rigged up a video camera, a frame grabber, and a networked computer to monitor the communal coffee pot in the Arup Building's Trojan Room (Stafford-Fraser 1999). 'CoffeeCam' (*www.cl.cam.ac.uk/coffee/coffee.html*), as it is often called, eliminated the frustration of climbing several flights of stairs only to find the carafe empty. Webcam technology blossomed in the mid 1990s, when inexpensive electronic cameras like the Connectix QuickCam (now produced by Logitech) fostered an upsurge of timely electronic photographs as well as numerous new websites catering to tourists, outdoor sports enthusiasts, and voyeurs (Krumenaker 1996). Among the latter websites is the JenniCam (*www.jennicam.com)* project of web pioneer Jennifer Ringley, who serves up snapshots from cameras strategically placed throughout her apartment (Tanaka 1999). For $15 a year JenniCam "members" can have their screens refreshed every minute, while "guests" may update only once every 15 minutes. Less risqué is KittyCam (*www.kittycam.com*), which offers free glimpses every two minutes of an elegant, long-haired black cat adopted in 1995 by the employees of Joint Solutions Marketing, a California consulting and design firm (Fredrickson 1998; Marder 1998). The following year the company bought a QuickCam—to photograph for the cover of an Apple Computer catalog. With the cover shot out of the way, employees installed the camera in the conference room and connected it to the firm's website. The resulting 'TableCam' was predictably boring, but someone suggested relocating the camera to focus on Kitty's favorite chair. The new theme proved remarkably popular—KittyCam averages two thousand visitors a day—and the company set up a separate website to commemorate its feline partner and feral cats in general. In summer 2000, the website began offering a variety of 'Kitty' merchandise, including the Kitty Mug, a Kitty Mousepad, and Kitty Coasters.

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Among the earliest cartographic references to webcams is Bill Thoen's April 1996 column in *GIS World*. Thoen, who operates a GIS-oriented bulletin board, observed a growing use of webcams to promote tourism, warn of traffic congestion, and illustrate temporal phenomena like plant growth and bacterial decay. The following year, in a paper on "New Media and Their Applications to the Production of Map Products," William Cartwright (1997) proposed the webcam as a "reality link" to provide the "ground truthing" without which some viewers have difficulty comprehending cartographic animations and other visually complex geospatial multimedia. Particularly promising are interactive webcams, designed to pan, tilt, and zoom under the user's control. More recently, Cartwright (1999) listed webcams with games interfaces as "hybrid tools" useful in enhancing the cognitive accessibil-

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ity and informativeness of Internet cartography.[1] And Fraser Taylor (1999), a cartographer with an early interest in Web technology, echoed the importance of webcam-based links to reality in "edutainment" (educational entertainment) multimedia.

Webcams, I will argue, have a wider role in electronic cartography. At the comparatively minute, local level, for instance, webcam images can serve as point symbols—and in some cases direction-specific point symbols—providing qualitative or quantitative information about places. At a broader level, webcams are a relatively conspicuous element of cartographic surveillance, a mode of map use concerned more with control and manipulation than with learning and understanding. Webcams also address the conventional didactic and explanatory functions of atlas illustrations, albeit with a very timely and often dramatic twist. And because webcams exist at discrete points on the earth's surface, index maps storing their locations are important to users interested in spatial knowledge or surveillance. Equally pertinent are comparatively large-scale maps pinpointing the locations of individual webcams within their immediate neighborhoods. This multifaceted complementarity of maps and webcams suggests a duality in which webcams enhance our appreciation of mapped phenomena and maps help users locate relevant webcams.

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WEBCAMS AS POINT SYMBOLS

The notion of webcam images as point symbols is not as farfetched as it might seem. Although I have yet to find a literal example, the small size of most webcam images would let a single map provide the geographic framework for a simultaneous display of multiple webcams. Figure 1, concocted by copying and pasting approximately simultaneous images from a traffic-monitoring website, illustrates what I mean. The icons are webcam images for various points along Interstate Highway 66, in northern Virginia. I found them on the Virginia Department of Transportation's HighwayNet (*www.highwaynet.com*), one of a growing number of traffic-monitoring websites (Lyons and McDonald 1998). VaDoT uses the website to promote its concern with traffic safety as well as help motorists avoid congested areas. Although pictorial images smaller than an inch or so wide are difficult to comprehend on both screen and paper, a regional map that allowed users to pan and zoom could support the website's ultimate collection of 110 webcams in the Washington, D.C. area. (In mid-August 2000, 25 cameras were in operation, and a FAQ page promised a fully operating system with 110 cameras in the near future.) Because the webcam can point in the opposite

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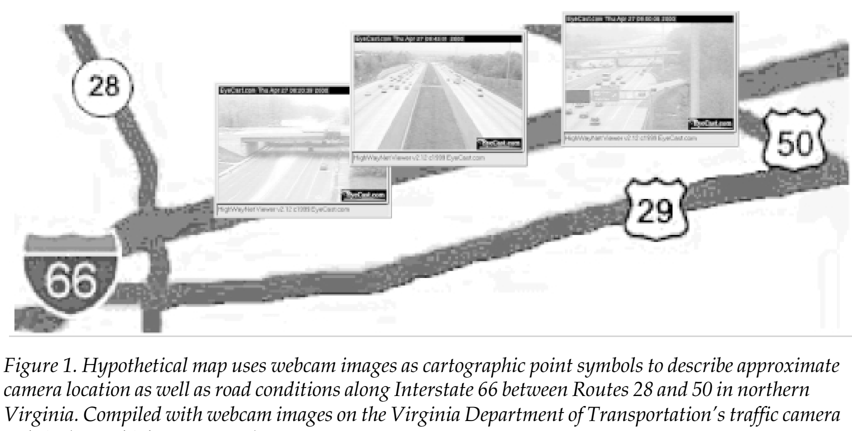

Figure 1. Hypothetical map uses webcam images as cartographic point symbols to describe approximate camera location as well as road conditions along Interstate 66 between Routes 28 and 50 in northern Virginia. Compiled with webcam images on the Virginia Department of Transportation's traffic camera website (www.highwaynet.com).

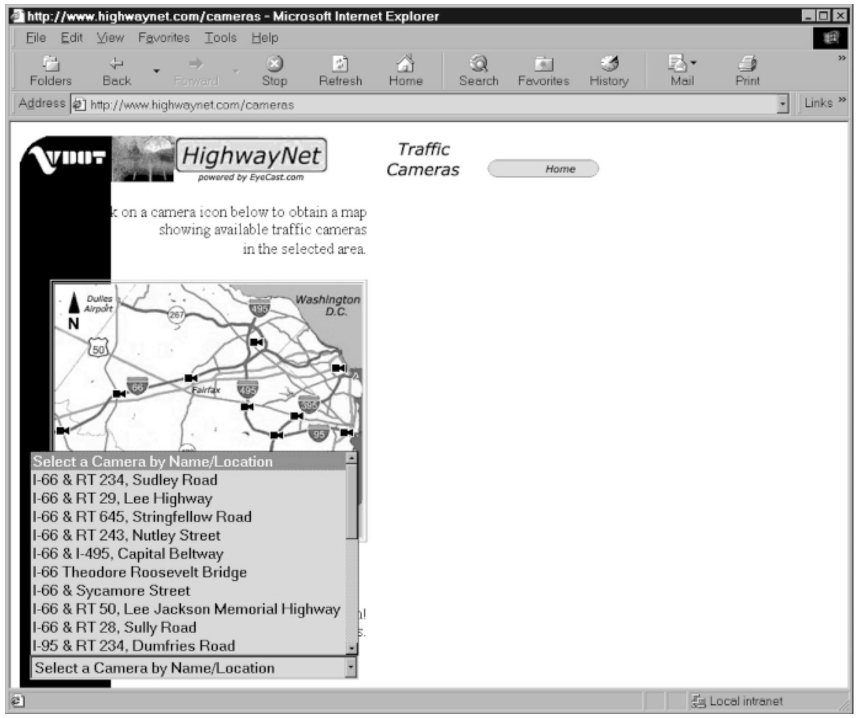

Figure 2. Virginia Department of Transportation's website provides a list of webcam locations as a pop-up menu atop an area map showing sections of highway with more detailed cartographic menus, as shown in Figure 3.

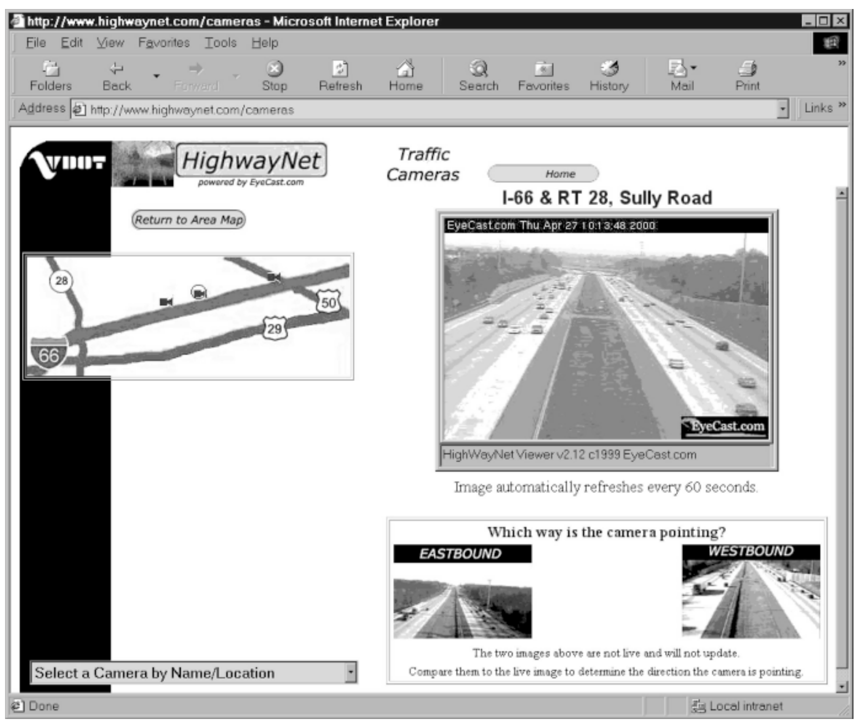

Figure 3. Webcam (right) shares the screen with a detailed index-map excerpt (left) on which camera-like icons show webcam locations. Faint circle surrounding the center icon marks the camera's location. Pair of example views below the webcam image helps the viewer identify direction in which the camera is pointing.

direction, sample east- and westbound images (lower right in Figure 3) are needed.

Virginia's traffic website displays its webcam links in two ways. A pop-up menu offers a scrollable list of locations, as shown in Figure 2, and a two-level hierarchy of index maps identifies camera locations with clickable camera-like icons as shown in Figure 2 (partly obscured) and in Figure 3 (at the more detailed level). By contrast, the LIVE Camera Shots website of Montgomery County, Maryland's Department of Public Works and Transportation provides motorists on the opposite side of the Potomac with a list of clickable labels identifying intersecting roads and arranged by area or route (as in Figure 4). Because a geographically sequenced list of links is a crude topological map of sorts, webcams function as point symbols even though the user cannot simultaneously view their respective scenes. In principle, linear lists of clickable point symbols are similar in structure to the American Automobile Association's TripTiks, Amtrak's route maps for individual trains, and other route-specific cartographic narratives.

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Traffic-flow websites illustrate the webcam's role as a quantitative point symbol. In showing the number of vehicles along a particular stretch of highway, the webcam offers a readily interpreted representation of traffic density and congestion (Figure 5). And if a rapid refresh rate allows multiple snapshots of moving vehicles, the webcam describes flow velocity as well as traffic volume. What's more, by allowing the viewer to count quickly the number of lanes that are open and moving freely, the webcam reveals the road's innate capacity as well as temporary constrictions caused by accidents or construction. In general, traffic webcams offer viewers four quantitative cues akin to the map author's visual variables (e.g., MacEachren 1995, 270-276): lanes of traffic, which

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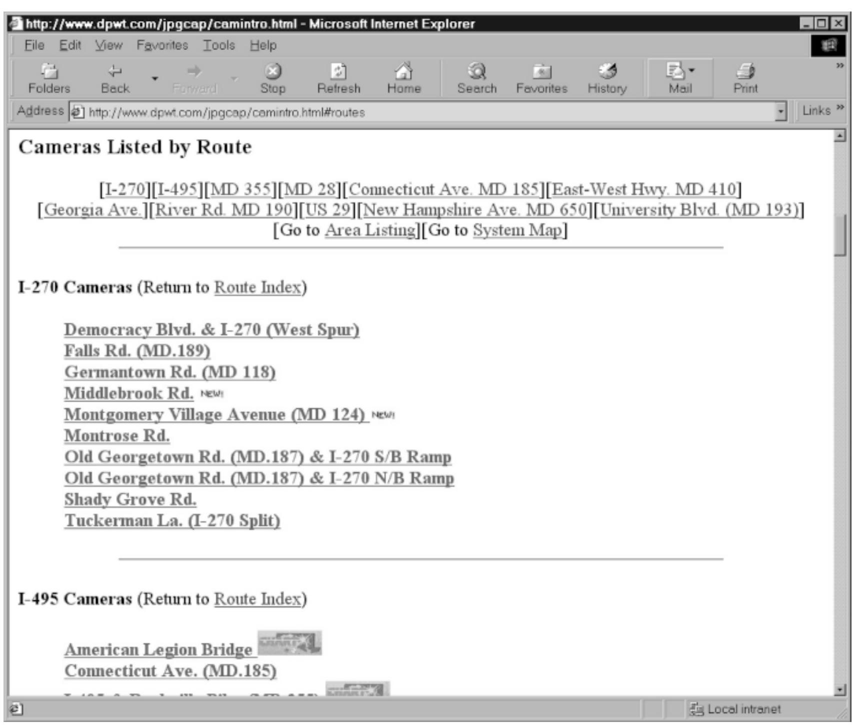

*Figure 4. On its LIVE Camera Shots website (*www.dpwt.com/jpgcap*), Montgomery County, Maryland's Department of Public Works and Transportation offers motorists a linear list of webcam links, organized by route.*

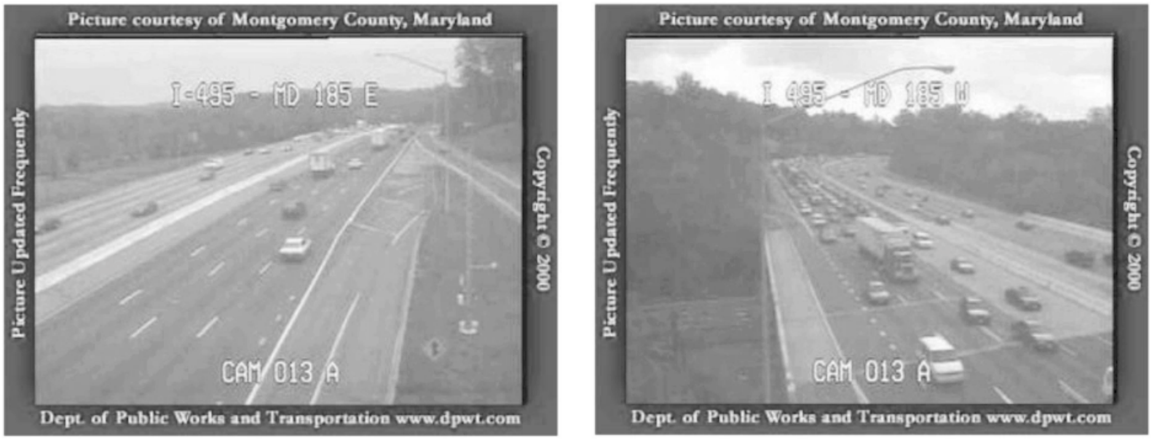

Figure 5. Webcam monitoring of Washington, D.C.'s Capital Beltway (I-495) at Connecticut Avenue shows different traffic conditions at 10:30 am (left) and 5:28 pm (right) on Wednesday, April 27, 2000. Note reversed camera orientations, to avoid direct sunlight.

reflects the road's functional width or *size*; the overall *numerousness* of vehicles, which indicates density of traffic and likely congestion; the *texture* or spacing of vehicles, which can reveal either the frustration of stalled traffic or the risk of a rear-end collision; and average speed, a dynamic variable that David DiBiase and his colleagues (1992) call *rate of change*. Although machine vision technology could convert each of these four cues into a number (Michalopoulos and Samartin 1998), the webcam affords a more direct, readily interpreted view of traffic flow than the comparatively abstract symbols with which conventional maps represent numerical estimates. Differences in the height and orientation of individual cameras thwart exact comparisons of webcams at different locations, but viewers familiar with the website and local highways should have little difficulty comparing routes and avoiding tie-ups.

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Traffic websites are not the only examples of webcam images serving as quantitative point symbols. Webcams monitoring beaches, recreation areas, and business districts afford visual assessments of crowdedness based on the numerousness of people, not vehicles, and cameras at websites for surfers portray (or at least suggest) the height of waves. For an example, visit Gary's Surf Cam (*www.netsurfing.com/surfcam*) for hourly photos from Surfside, Texas, and links to forecast maps showing wave height and predominant wave direction in the Gulf of Mexico.

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At weather and tourist websites, where sunshine is a key concern, webcams employ another quantitative visual variable, *value*, which registers cloud cover in addition to obvious seasonal and diurnal effects on solar radiation. Like most other imaging instruments, webcams respond readily to visible light, and few cartographic symbols employ value as effectively as sensors able to contrast the bright backgrounds of clear, sunny days with the less inviting scenes of overcast or stormy skies. However difficult the exact comparison of different locations, weather webcams offer viewers a quick check on sunshine and visibility as well as a qualitative assessment of the presence and type of precipitation. And full-disk and continental cloud-cover images (Figure 6) transmitted every quarter or half hour from geostationary meteorological satellites—perhaps the ultimate webcams—extend the analogy even further. In this latter case, though, cartographic processing clarifies the raw images by adding appropriately projected coastline symbols.

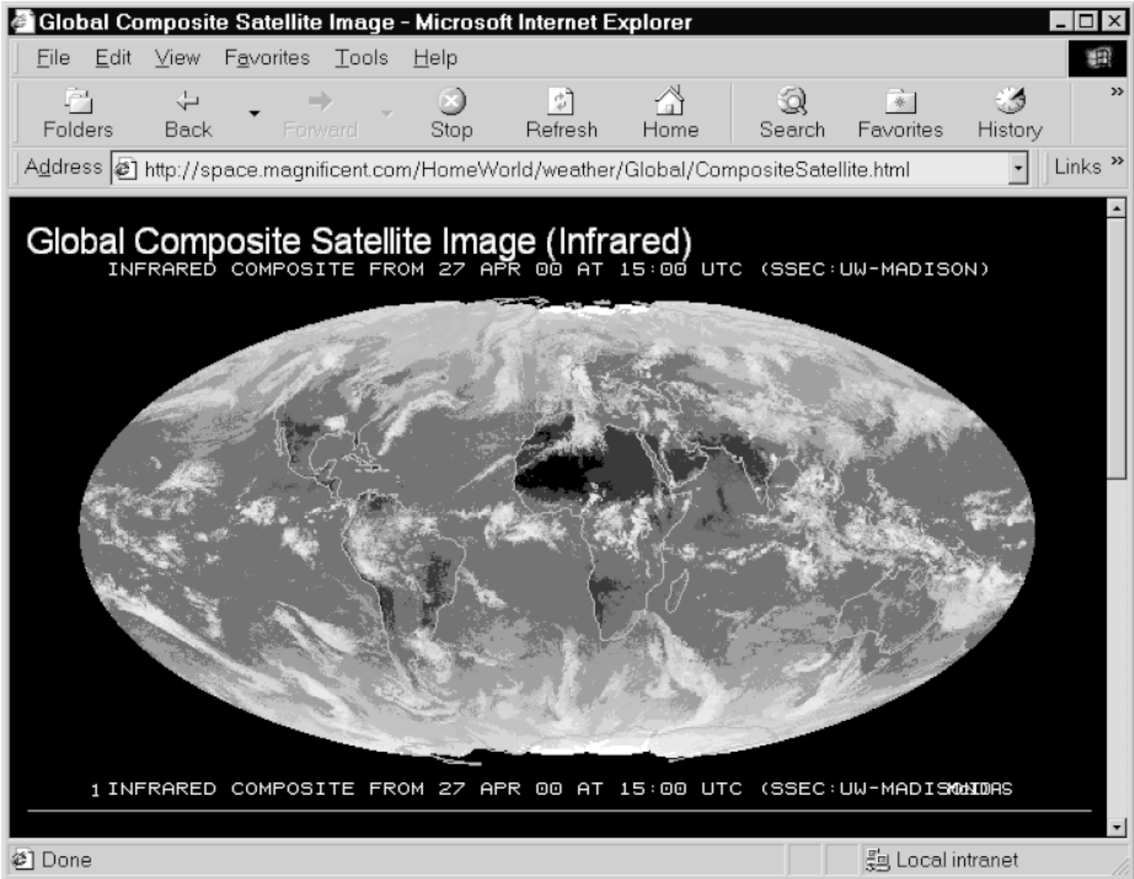

Figure 6. Composite of three transformed infrared satellite images prepared by the Space Science and Engineering Center at the University of Wisconsin—Madison.

Although weathercams and surfercams often blur distinctions between the qualitative and the quantitative, webcams as point symbols are more likely to highlight differences in kind than differences in amount or intensity. Indeed, powerful, often highly emotive contrasts in shape and hue underlie the popularity of webcams, which can capture the beauty of a sunset or pristine beach as well as the ugliness of a garbage dump or encroaching strip mine. As cartographic elements, webcams exemplify the map's prowess in communicating a selective, if not biased view of reality. A tourist website thus points its camera toward a historic home or spectacular seascape, rather than an overflowing trashcan or the impatient queue in front of a public toilet. In the same self-promoting vein, an environmental group would surely focus on a manufacturing plant's smokestack or polluted stream rather than the well-landscaped administration building or the new sport utility vehicles in its employee parking lot. Although webcams afford 'reality links' and 'ground truthing,' viewers must be wary that maps, photographs, and webcams, particularly in combination, can present a purposefully selective, highly rhetorical landscape narrative.

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This caveat applies to interactive as well as fixed webcams. Viewers allowed to turn and tilt the camera are constrained nonetheless by a fixed pivot point chosen (one might assume) to afford multiple views, good or bad, that support the site owner's position. As developers of game software have demonstrated, interactivity can be seductively engaging—and the key to making virtual and on-line environments believable (Houser and DeLoach 1998). Engaging the viewer's attention and prolonging the session can make the experience both memorable and believable.

WEBCAMS AS ATLAS ILLUSTRATIONS

As educators and authors of school atlases are well aware, maps and photographic images are inherently complementary. Learning, after all, depends upon a variety of devices, among them writing, pictures, and various diagrams, including maps, which excel at describing relative distances, geographic shapes, routes, patterns of distribution, and landscapes in general. But because many maps are collections of abstract geometric symbols, carefully chosen photographs can provide a useful bridge between the symbol and the viewer's experience. A map on which a small colored circle identifies a city as a tourist mecca is less effective than the atlas or guidebook that depicts a landscape of attractive scenery, intriguing landmarks, comfortable inns, and inviting restaurants. And it's easier to appreciate a map of tropical farming if images of rice paddies and toiling peasants are nearby. If a webcam's link to a particular map symbol is especially strong (as in Figure 3), the symbol-photo pair clearly qualifies as a 'self-describing symbol,' defined by Suzette Miller (1999, esp. 57-58) as carrying its own description and requiring no map key (except perhaps to show the camera's location and orientation).

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William Cartwright and Michael Peterson (1999) have remarked that the world atlas is perhaps the quintessential metaphor for multimedia cartography. Microsoft's Encarta Interactive World Atlas 2000 illustrates their point with a display engine that can integrate maps with pictures on the fly (Jacso 1998). The atlas's Multimedia Map is an interactive globe, which the viewer can rotate as well as enlarge or shrink. To the left of the map, a menu offers a choice of themes: people, places, landscapes, agriculture and industry, animals, and "all." As the viewer moves the mouse pointer across the map, three or four small rectangular frames in the vicinity become active (Figure 7). These frames, which contain thumbnail photos of the chosen variety, are roughly a centimeter tall on my monitor. In each frame Encarta cycles through a set of different pictures, which describe scenes in the vicinity. A highlighted border around the closest frame invites the viewer to launch a small window with a larger view, a verbal explanation of the scene, and a series of thumbnail images, which can be enlarged and viewed as a slide show. (Elsewhere within its main menu, the atlas offers a number of video articles describing various aspects of an area's culture, economy, or landscape.)

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An embedded web browser links the user to a dedicated website (*encarta.msn.com/ewa*), which serves as an alphabetical index of place-specific directories for retrieving a vast variety of images too numerous and demanding for a pair of CD-ROMs. Although few of the websites indexed have their own webcams, many sites' own links often point directly or through a 'search' function to other local websites with webcams. Closer integration of the atlas software with the browser—the Justice Department's Anti-Trust Division not withstanding—would allow webcams to support an interactive display similar to the atlas's Multimedia Map. However intriguing, this design relies on high-capacity bandwidth connections and, perhaps more problematic, depends upon a suitable variety of predictably reliable webcams. Darkness is less troublesome because stored images (or indoor alternatives, perhaps) might compensate for the inevitable limitations of outdoor webcams in parts of the world temporarily on the dark side of the circle of solar illumination.

Figure 7. Excerpt of pop-up photo images from the Multimedia Map in Microsoft Encarta Interactive World Atlas 2000 illustrates a potential use of webcams in a real-time interactive world atlas.

In any event, a fuller integration of webcams with world and regional atlases seems inevitable when improved bandwidth makes the CD-ROM atlas obsolete.

WEBCAMS AND THE MAP INDEX

Webcams depend on maps in two fundamental ways: to help users find a camera relevant to their needs and to describe a camera's location and perhaps its footprint or viewshed. As the Virginia highway webcam in Figure 3 demonstrates, a sectional map might play the role of both locator map and map index, whereas a less detailed map covering the entire area (Figure 2, partly hidden by the pop-up menu) is little more than a cartographic index for the website's ten multi-camera locator maps. This hierarchical, two-tiered organization is useful if not essential, given the modest resolution of computer monitors and the complexity of describing sophisticated multi-camera websites.

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Montgomery County, Maryland's trafficams illustrate a somewhat different approach. To help viewers find the most suitable camera, the LIVE Camera Shots website supplements its route-oriented lists of camera locations with a clickable county index map (Figure 8) linked to four regional index maps describing dozens of cameras located along principal streets (Figure 9). The latter maps provide a more detailed geographic frame of reference than their Virginia counterpart (Figure 3). Individual webcam images are presented without an adjacent locator map.

Inadequate index and locator maps are a deficiency of many geographically useful webcam directories. Sites lacking a cartographic index as well as locator maps include AfriCam (*www.africam.com*), an ecotourism website with links to 14 cameras in African national parks, and the Live Weather Images (*www.weatherimages.org*) website's worldwide listing of several hundred "weather and tower cams." Although the

Figure 8. Clickable countywide index map provides links to four comparatively detailed index maps showing traffic webcam locations in different sections of Montgomery County, Maryland.

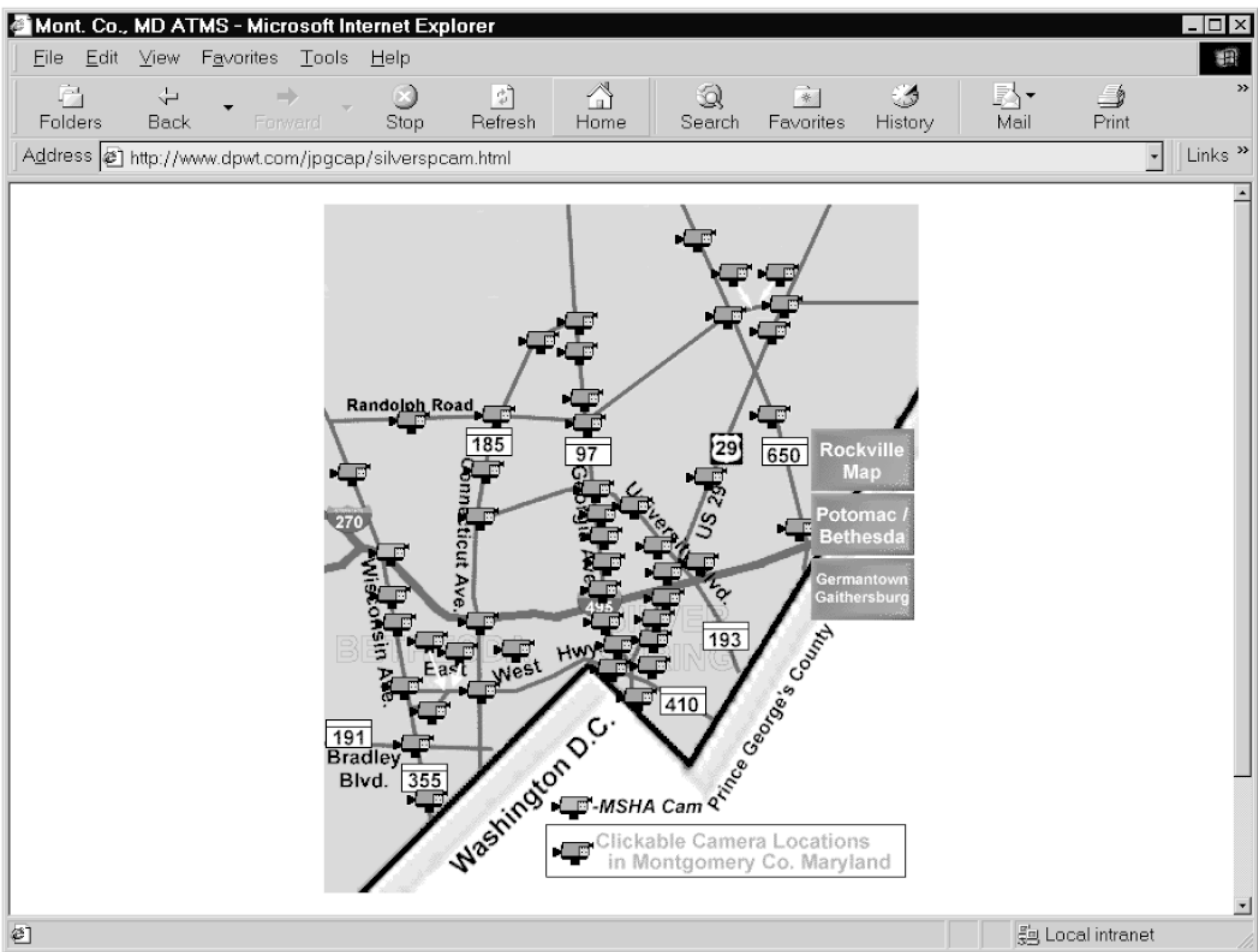

Figure 9. Detailed index map pinpoints traffic camera locations in the Silver Spring section of Montgomery County, Maryland.

seriousness of missing index maps is easily exaggerated—most surfers or weather enthusiasts, I suspect, are content to find a camera only vaguely representative of a particular coast or country—the lost opportunity to impart geographic knowledge is unfortunate. By contrast, the World Map of Live Webcams (*dove.mtx.net.au/~punky*) makes effective use of a two-tier clickable index map that identifies cameras temporarily out of service and offers the picture of a globe suitably turned to show areas currently with daylight (Figure 10).

Although index maps (when offered) seem suitable, locator maps are almost always vague about the area covered by the camera. As with index maps, additional information might prove unnecessary if not useless for most viewers. Traffic websites, for which location is indeed relevant, communicate camera locations effectively with a combination of words, highly generalized maps, and directional keys, while tourist websites, not intended for wayfinding, need nothing more than a well-chosen view and a verbal description.

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WEBCAMS AND THE CARTOGRAPHY OF SURVEILLANCE

However adequate the design of most webcam index and locator maps, none that I encountered is as detailed as a map published a couple of years ago in *The Atlantic Monthly* (Reeder 1998). Compiled by University of Kentucky geographers Matt McCourt and Carl Dahlman, the map described the assumed footprints of more than 70 surveillance cameras in a three-block section of Midtown Manhattan. Innovative symbols illustrated each camera's range and differentiated fixed cameras from dome-housed cameras able to pan. Although none were webcams, the

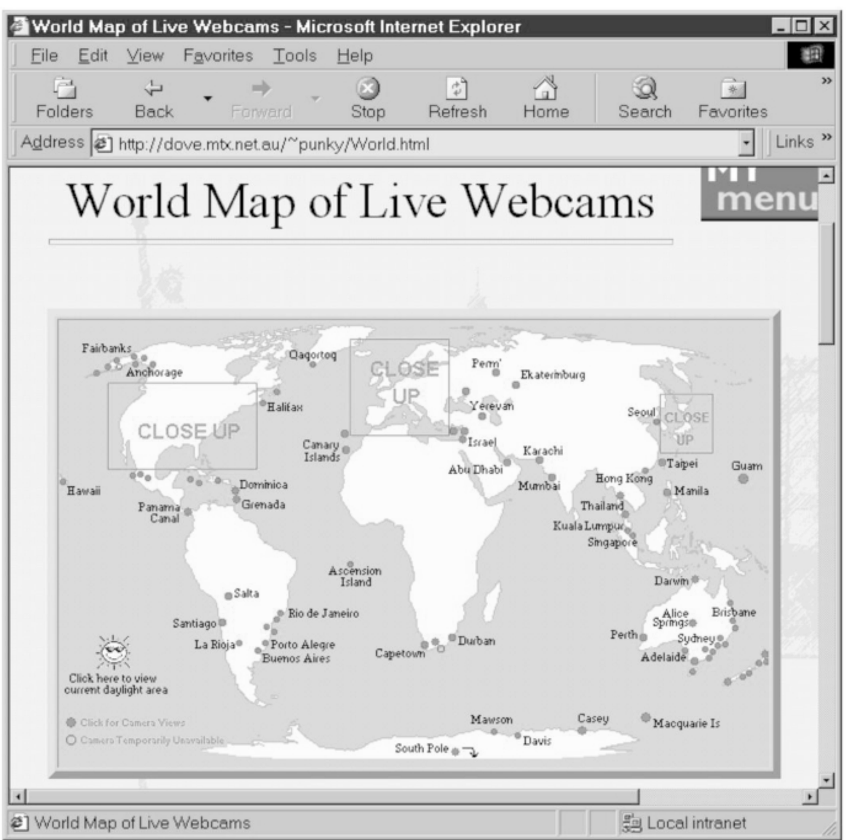

Figure 10. Primary cartographic index of the World Map of Live Webcams, a clickable Australian directory with more detailed index maps for the United States, Europe, and Japan.

map was a powerful rhetorical statement of the threat of security cameras to personal privacy in public places.

The *Atlantic* map suggests an ominously Orwellian scenario in which similar symbols are the key elements of an interactive, hierarchical directory to a web of surveillance cameras throughout our business districts, neighborhoods, and parking lots. The technology is straightforward, and the cost is not beyond the pocketbook of an electorate overcome with fears similar to those of Manhattan building owners. What better way to warn off villains than to suggest the steady stare of electronic eyes with which anyone—surely someone somewhere, anywhere—might be watching. With millions of little brothers (and little sisters) watching, who needs Big Brother?

"The Atlantic *map suggests an ominously Orwellian scenario . . ."*

Were I a postmodern critical theorist, this would be my cue to invoke the Panopticon, a late-eighteenth-century invention of British philosopher Jeremy Bentham as well as a favored emblem of the late Michel Foucault and kindred spirits who write of the "panoptic gaze" of the "panoptic state" (e.g., Staples 1997, 27-29; Whitaker 1999, 32-48). Bentham proposed a prison that kept prisoners under constant scrutiny with a one-way viewport through which an unseen "inspector" could (if he chose) monitor an inhabitant's every move at any time. However fashionable among postmodern theorists and privacy advocates, Bentham's impressively intriguing diagram seems as useful a concept as the equally naïve drawings of nineteenth-century flying machines that wouldn't fly and were never built. Even so, strident proponents of the Panopticon hawk dire warnings laced with blatant technological determinism, and one recent writer includes the webcam in his list of threats to personal privacy (Garfinkel 2000, 110-112). It's possible, I concede, but hardly likely. Other monitoring systems are more efficient, and other threats to personal privacy—GPS-based location tracking and signal-intelligence monitoring networks with automatic speech-to-text conversion come readily to mind—are more intriguing if not more plausible.

". . . it's equally clear that twenty-first century cartography will be very much a cartography of surveillance, . . ."

That said, it's equally clear that twenty-first century cartography will be very much a cartography of surveillance, capable of monitoring a broad range of threats, environmental and military as well as criminal, and posing ethical dilemmas no less daunting than the problems of genetic cloning explored in Aldous Huxley's prescient 1932 novel *Brave New World*. Webcams and their cartographic directories will no doubt have at least a minor role in geographic surveillance, perhaps with much the same collective clout as personal and community webpages touting news and entertainment. No less intriguing than the Panopticon is the prospect of millions of avid geoexhibitionists, proud of or embarrassed by their surroundings and clamoring for the attention of a mass audience of curious cartovoyeurs.

NOTES

1. Oddly Cartwright and co-author Gary Hunter (1999, 268) do not mention webcams by name in a list of distributed information for "the Literate Traveler." Even so, their list includes a variety of web-delivered pictorial information, including photographic collections, broadcast television, and Real Audio Web television.

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