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A Mirror of Our World: Google Earth and the History of Cartography

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Abstract: Google Earth is widely admired as one of the most advanced and powerful products of modern computerized cartography. It has been praised as a revolutionary new way of viewing the earth, as the first convincing attempt at a mirror-world or a simulacrum of the earth. Nonetheless, Google Earth is deeply rooted in the practices and conventions of Western cartography. This article examines what is new and what is old in Google Earth. It especially focuses on the extent to which Google Earth constitutes a mirror world, and on the philosophical meaning and validity of such concepts as cartographic mirroring and representation. It also speculates about the possible future development of Google Earth and similar efforts to mirror the world in digital form.

Keywords: Google Earth; history of cartography; maps; atlases; virtual reality; mimesis; representation; mirror worlds; simulacra

The Wonder of Google Earth

Google Earth is arguably the most impressive cartographic achievement of the twenty-first century (at least so far). It is remarkable for its relatively detailed and comprehensive coverage of the earth's surface, for its speed and flexibility, for its relative ease of use, and for its ability to incorporate new information from users.

Although there are several similar programs (most notably Microsoft's Bing Maps, formerly called Virtual Earth), none have so far been able to match Google Earth in popularity. According to one source, as of February 11, 2008, Google Earth had been installed on at least 350 million computers.[NOTE 1] Since then, a version has become available for Apple's *iphone*, which has doubtless helped increase the number of installations. It is also much discussed in blogs, the popular press, and scholarly publications.[NOTE 2]

It is not hard to understand why this program has become so popular. It is a remarkable experience to open Google Earth and see our planet suspended in virtual space on a computer screen, and then to dive through increasing levels of detail to the point where one's own house becomes visible. It is wonderful to view detailed, three-dimensional images of most of the earth's surface—to rotate and tilt them, to examine them at various angles, and to see them illuminated in different ways by the sun. As if this is not enough, Google provides a rich display of supplementary information about many places: historical maps, hiking trails, photographs, three-dimensional views of buildings, traffic information, along with the locations of banks, restaurants, bars, filling stations, and much more. For those not satisfied with learning about the surface of our planet, it also includes the oceans, Mars, the moon, and a telescopic view of outer space.

In my opinion, Google Earth's popularity is justified. One can get a better sense from Google Earth than from any other single source of what a particular place is like, such as an obscure island off the coast of Canada. It accomplishes this by enabling us to view three-dimensional images, supplemented by multiple layers of information (such as roads and landmarks), along with photographs, and often hyperlinked articles and even videos.

Google Earth is also impressive just in terms of its size and its cost. Statistics about Google Earth are hard to come by, but it incorporates many terabytes of data, which are divided into more than 100,000 tiles. It must have taken countless hours and enormous amounts of money to create. If nothing else, it is an impressive display of the powers of modern technology and capitalism to mobilize resources.[NOTE 3]

It is not often in the modern world that the sense of wonder is evoked, but Google Earth has done just that. It is not only powerful and useful, but it creates a strong sense of virtual reality, and has been widely described as a mirror world, a second world, a virtual earth, or a simulacrum. One blogger has commented:

> As a simulacrum of the Earth, Google Earth provides a safe space for unlimited voyeurism. You have instant access to forbidden or dangerous places—North Korea, Mecca, the Kremlin, the favellas of Rio, the top of Everest. But mostly it's fun to hop around. Freed from physical constraints, the Google Earther perceives the planet as small, manageable, knowable, and interconnected. This bonhomie can be exhilarating.[NOTE 4]

Another blog, *Ogleearth*, which is dedicated to exploring Google Earth, sometimes contains discussions of Google Earth as a mirror or simulacrum. One *Ogleearth* blogger makes an interesting (although highly debatable) comparison between Google Earth and traditional atlases:

> Brainy improvements improve the quality of the information that Google Earth delivers, or improve the efficiency of access to existing information—they improve the function of Google Earth as an atlas. Beauty improvements, on the other hand, improve the function of Google

> Earth as a plausible mirror world, an ever-more accurate simulacrum of Earth.
>
> Atlas or mirror world, what's the difference? Their functions are in fact poles apart. Atlases filter out as much as possible that which is not information or which obscures information. Mirror worlds, on the other hand, aim for the accents and details that provide a sheen of reality —precisely that which atlases strip off in the pursuit of clarity. Atlases try to augment reality by pushing high-information content to the fore. Mirror worlds do not." [NOTE 5]

This provocative quotation raises further questions: What, exactly, is the relationship between Google Earth and older forms of cartography? To what extent is it valid to describe Google Earth as a simulacrum, a mirror-world, or as a form of virtual reality?

What is Old in Google Earth

To a person knowledgeable about the history of cartography, there is something familiar about this enthusiasm for Google Earth, and about the description of it as a simulacrum or mirror world. This reaction is not unlike the wave of enthusiasm that greeted the initial appearance of atlases in the sixteenth century. The very names of some of these early atlases imply that their creators saw them as somehow mirroring the world: Ortelius' *Theatrum Orbis Terrarum* (Theatre of the Earthly Orb), and De Jode's *Speculum Orbis Terrarum* (Mirror of the Earthly Orb), and Lucas Janszoon Waghenaer's *Spiegel der Seefahrt* (published in English as *The Mariner's Mirror*).[NOTE 6]

The idea that atlases can mirror the world was also expressed in contemporary commentaries. Thus, the 1598 French language abridgment of the *Theatrum* contains a prefatory ode that concludes: "This book by itself is the entire world; the entire world is but this book."[NOTE 7]

The idea that the world can be mirrored through symbolic representation was not confined to the sixteenth century, or even to maps. Here is a description of the pleasures of armchair travel (sometimes attributed to John Locke) from the preface to Awnshawm and John Churchill's *A Collection of Voyages and Travels* (1704):

> To conclude, the empire of Europe is now extended to the utmost bounds of the earth where several of its nations have conquests and colonies. These and many more are the advantages drawn from the labours of those who expose themselves to the dangers of the vast ocean, and of unknown nations; which those who sit still at home abundantly reap in every kind: and the relation of one traveller is an incentive to stir up another to imitate him; whilst the rest of mankind, in their accounts without stirring a foot, compass the earth and seas, visit all countries, and converse with all nations. [NOTE 8]

The conception of cartographic mirroring is not limited to Western culture. In eighteenth-century Korea,

the author of an atlas of China remarked:

> A scholar who never travels but stays at home is not worthy to be accounted a scholar. From my youth on I had the ambition to travel, but could not afford to wander over the three hundred counties of Korea, much less the whole world. So, carrying out an ancient practice, I drew a geographical atlas. And while gazing at it for long stretches at a time I feel as though I was carrying out my ambition . . . Morning and evening while bending over my small study table, I meditate on it and play with it and there in one vast panorama are the districts, the prefectures and the four seas, and endless stretches of thousands of miles. [NOTE 9]

The notion that a map can somehow mirror the world remained a common trope in western cartography until well into the nineteenth century, and it lingered in some scholarly places into the twentieth. Only gradually did academics and map makers start to think about the intellectual problems raised by regarding a map as a literal representation of the world. The mirror-world concept started to be questioned around the time that Lewis Carroll (Charles Lutwidge Dodson) wrote his gentle satire about cartographers in a fictional country who drew a map at a scale of a mile to a mile, which was never used because farmers complained that it would block the sunlight if it was spread out over the earth— forcing the map makers "to use the country itself as its own map," which served "nearly as well." [NOTE 10]

The idea that a good map somehow mirrors the surface of the world was not completely abandoned in academic circles until recently. The reaction against this notion has been particularly strong among scholars influenced by postmodernism, which tends to focus almost exclusively on the relationships between signs and symbols, rather than on their relationship to external "reality." This trend has been taken to its extreme by the ingenious Jean Baudrillard, who has gone so far as to assert that not only is it impossible for a map to mirror reality, but that reality itself does not exist, and that therefore simulation "has no relation to any reality whatsoever."[NOTE 11]

In my view, this trend towards denying that maps have any mimetic function at all has taken the reaction against the naïve view that a map can literally mirror the world much too far. This article assumes that maps (including Google Earth) have some kind of relationship to a "reality," which is "out there." This is not to deny that the ultimate nature of that reality is unknown and possibly unknowable, for the reality we perceive is inevitably filtered through our physiology, mental processes, and cultural conditioning. Maps both mirror and help create the only reality we know, which is derived from our own conditioned perceptions of the external world. This epistemological view makes possible more complex and sophisticated conceptions of "mirroring" than can be found in most of the literature on this subject.[NOTE 12]

Today, we may find it hard to understand why early atlases were greeted so enthusiastically as mirrors of the real world, but there are substantial similarities between Google Earth and these atlases—as well as in the reactions both have evoked from their users. A comparison of the similarities and differences between Google Earth and early atlases reveals much about both the nature of maps, and about the development of cartography since the European Renaissance.

Of course, neither Renaissance atlases nor Google Earth are mirrors of the world in any literal sense. We now have no trouble seeing this with early maps, but Google Earth is so powerful and so full of

technological tricks to give the appearance of reality to its images, that the casual user may be excused for succumbing to the illusion that it displays the world in miniature on a computer screen. But it still goes almost without saying that Google Earth comes nowhere near to mirroring the earth's surface; like all other cartographic productions, it is a highly selective representation based on our perceptions of the world.

Thus, the stereographic view of the earth (initially focused on North America), which appears on Google Earth's opening screen, looks much more like a conventional globe than a satellite view of the earth (see Figure 1). Although its image of land areas is clearly derived from low-resolution satellite imagery, the earth is presented as cloud free, and continents and political boundaries are outlined in yellow. The oceans are colored in blue, but appear to be drained of water to reveal the ocean floor. Whatever else it may be, this is not a realistic view of the earth floating in space.

Figure 1. Opening Screen from Google Earth.

What we see here is the earth as we have learned to perceive it. We accept this as a true image of our planet in part because we have been trained to do so by several centuries of map and globe makers. It is no coincidence that this image resembles both a conventional globe and the famous "earth from space" satellite image. The idea that the earth can be represented in this way can be traced back to the theories of Ptolemy

and other ancient Greeks, but the first globes and hemispheric projections showing the continents approximately as we know them go back to sixteenth-century maps and atlases. At the same time, it cannot reasonably be denied that there is some kind of real, if stylized, relationship between this image and the earth as it really appears when viewed from outer space.[NOTE 13]

The larger-scale satellite images and aerial photographs in Google Earth, which are revealed when you zoom in, also do not reflect the world exactly as it really is. These images are also almost always free of clouds, which is not the usual condition for much of our planet. In addition, as is well known to those familiar with remotely-sensed images, their production involves numerous distortions and manipulations, including such things as "corrections" to bring them in line with map projections, and various types of image manipulation to highlight certain features on the ground. In the case of Google Earth, different places are represented in greater or lesser detail. High resolution images are presented for urban areas (especially in the United States and Western Europe), national parks, and other areas of widespread interest. Ordinary landscapes in rural areas are shown at a lower resolution, and places deemed important for national security are also not shown in detail. Thus, even the most seemingly realistic features of Google Earth—its aerial photographs and satellite images— cannot seriously be said to represent the world as it really is, even though a case can be made that they come closer to mirroring the surface of the earth than, say, a topographic map.

If even the most basic bare-bones features of Google Earth do not mirror the world, this is even more obviously true of its numerous clickable layers and other add-ons. Most of these do not even pretend to show features of the earth as they would appear to a visitor peering at it from outer space.

Not only is the hemispheric projection on the opening screen a product of our particular cartographic tradition, but so are the ways in which the detailed maps in Google Earth are organized and displayed. Most of these features in Google Earth were anticipated in atlases and other products of Western-style cartography from the Renaissance through the twentieth century.

For example, one of the defining characteristics of Western cartography is the use of latitude and longitude coordinates to pin down the locations of places and things. Google Earth exemplifies this approach to cartography, as the geographic coordinates of virtually everything displayed by the program is built into its underlying coding, and this geocoding is critical for the functioning of the software.

The use of mathematical projections to display the curved surface of the earth on a flat surface is another characteristic feature of post-Renaissance Western cartography. Google Earth could not function without using some form of projection, although the projection it uses is unusual. Once one zooms in to a certain point past the initial hemispheric projection, the displays are based on the equirectangular projection (also known as the "plain chart" projection). This is one of the oldest and simplest projections, and it is not highly regarded by professional cartographers, since it ignores the curvature of the earth, and draws distances and directions between places as though the earth were a flat sheet of paper (or a flat computer screen). This projection distorts distances, directions, and land forms; but, in spite of these weaknesses, it was reportedly chosen by Google earth because it supports panning in all directions.[NOTE 14]

The use of this projection does not pose serious problems for small geographical areas, such as cities.

But those interested in overlaying medium or small scale or regional maps should keep in mind that images of conventional maps will not align properly with the underlying Google Earth images unless the overlays are themselves distorted by "rubber sheeting." This can create obvious problems for anyone wanting to compare old maps with their modern counterparts.

Another defining characteristic of western cartography is the use of uniform scales for individual maps. A conventional paper atlas can, of course, be made up of maps with different scales. The concept of "scale" takes a different form in digital cartography, since digital maps have no inherent scale, and can be displayed at various scales.

Nonetheless, the concept of scale is still very important for Google Earth. As an optional feature, you can turn on a "scale legend," which shows in bar form the scale of the map display you are viewing —optionally in either meters or feet per unit. On my computer screen, the units of the scale bar measure about 8.5 cm. or 3.4 inches per unit. At any given zoom level, the displayed scale varies slightly as you pan around the map. You can zoom in to a maximum scale of three meters (or eight feet) per unit. This scale is, however, much larger than is required to support the amount of detail that can be displayed at Google Earth's highest resolution. In practical terms, the largest scale that Google Earth can display is about 100 feet per unit. Although this way of displaying scale could clearly use some improvement, it is basically an adaptation of the conventional concept of scale for a digital environment.

All of the above features reflect our culture's emphasis on describing the surface of the earth in mathematical terms. It would not be going too far to say that the definitive characteristic of Western cartography is its reliance on applied mathematics. Computerized cartography, including Google Earth, not only follows this tradition, but takes it several steps further. When reduced to its basic elements, Google Earth is nothing but a long string of ones and zeros, which are manipulated by complex and sophisticated mathematical algorithms, to produce its realistic looking portrayal of the earth.

In several other respects, Google Earth can be seen as adapting the traditional atlas format for the online environment. In some ways, early atlases can be described as primitive "multimedia" productions. Even in the sixteenth century, atlases combined maps with textual descriptions, and with illustrations of people, animals, and buildings. More modern atlases often include photographs and satellite images. Google Earth has taken this process several steps further by adding such things as hyperlinks to sound and videos, but there is nothing conceptually new about this combination of "cartographic" and "non-cartographic" elements.[NOTE 15]

Google Earth's inclusion of numerous three-dimensional buildings is an interesting example of this process of adaptation. Google Earth's structures are non-cartographic constructs, which are basically models of buildings that can be viewed from all sides and angles. Displayed on a computer screen, they nonetheless resemble nineteenth-century bird's-eye views, and atlases that include three-dimensional drawings of buildings.

Another example of the way in which Google Earth has adapted traditional cartography is its treatment of elevation. The designers of Google Earth clearly made a conscious decision to abandon contour lines (although good contour maps can be found on Google Earth's cousin Google Maps). They opted instead for

three-dimensional digital elevation models, which give the illusion of elevation and depth through the use of perspective and shading. In this, they have chosen an older, but less exact, means of showing relief. Those who want precise elevation data can still obtain it from Google Earth, since the elevation and geographic coordinates of the cursor position are displayed on the bottom of the Google Earth screen.

What is new in Google Earth

Although, in many respects, Google Earth can be described as an electronic version or extension of a traditional atlas, it departs from paper atlases in several significant ways.

Probably the most dramatic single difference between Google Earth and all paper atlases is the ability Google Earth users have to rotate and tilt three-dimensional images. This striking feature enables users to get a much better sense of the topography of an area than can be obtained from a paper map. It also challenges conventional views of what constitutes a map or a cartographic image. Although there is little agreement among scholars on how to define the word *map*, maps are usually considered to depict the earth's surface from a vertical or nearly vertical perspective.[NOTE 16] But in Google Earth it is possible to tilt the landscape up to 90 degrees and view it from ground level—thus creating what would usually be described as a landscape view rather than a map (see Figure 2). Google Earth’s ability to bridge these two genres using the same data set suggests the artificiality of the distinction between maps and landscape drawings, which has previously been noted by some historians of conventional paper maps.[NOTE 17]

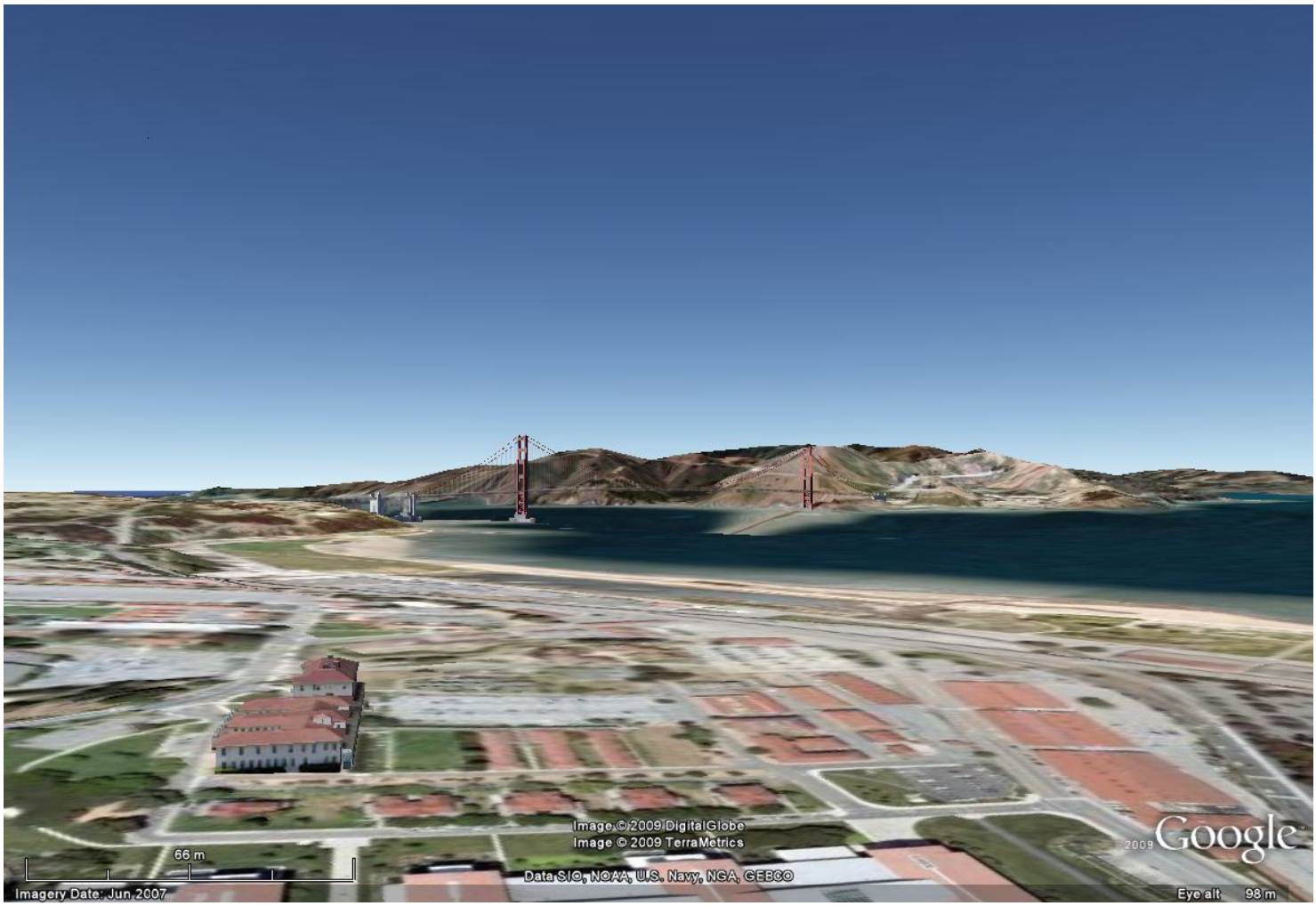

Figure 2. Oblique View of the Golden Gate Bridge from Google Earth.

Although Google Earth's ability to morph from vertical to horizontal views is something new, it is not entirely unprecedented in the history of cartography. Even in the eighteenth century, it was not uncommon for topographic maps to be accompanied by landscape views of the same subject. Although not nearly as powerful and flexible as Google Earth with its ability to zoom, rotate, and tilt images, these early efforts to combine maps with perspective views address the same need as Google Earth, in that both attempt to clarify geographical relationships by displaying them in different ways—thereby facilitating the users' understanding of the salient features of a place.

It should also be mentioned that the ability to juxtapose ordinary photographs taken at ground level with tilted landscape images is one of the features in Google Earth that enables users to obtain much more realistic and comprehensive views of landscapes than can be obtained from either maps or photographs alone. It is even possible in Google Earth to “fly into” an aerial photograph from a landscape view.

Even more important from the standpoint of the history of cartography, is the ability of Google Earth to store and display massive amounts of information. Imagine that someone tried to print out from Google Earth all of the maps that could possibly be created using all of its possible scales, perspectives created by tilting, layers, KML files, and other features. The resulting number of sheets of paper would not be infinite, but it would be very, very large. It would take at least a major library to house them, and if they were bound

together as paper atlases, they would occupy thousands of volumes.

Thus, Google Earth solves a problem that, shortly before its appearance, had been threatening to overwhelm the publishers of conventional atlases: the proliferation of cartographic information in digital form, and the difficulty of atlas publishers in keeping pace with it. The 1960s and 1970s saw a dramatic increased in the publication of specialized thematic atlases based largely on digital data. Writing shortly before the appearance of Google Earth, Barbara Bartz Petchenik noted that atlas publishers were being overwhelmed by the availability of large amounts of geospatial information, and by the growth of highly specialized user groups needing narrowly focused atlases. She presciently observed that electronic atlases might be the answer to these needs and difficulties.[NOTE 18]

The last decade has demonstrated the insightfulness of Petchenik's analysis. Although other online cartographic products have helped overcome this information bottleneck, Google Earth best exemplifies the new path taken by electronic atlases. Not only does it store more information than a multitude of paper atlases, but it presents only what a particular viewer requests—and does so quickly and easily. Thus, it is able to respond to the needs of a multitude of specialized users. Its ability to do this is enhanced by its extensive use of hyperlinks to supplementary materials, including music, photographs, videos, and text.

Special note should be made of Google Earth's ability to incorporate large amounts of user-provided information. Some of this (photographs from Panoramio) can be submitted by anyone and viewed by all Google users without downloading. Many of these add-ons are paid advertising. The most important type of this third-party content consists of KML files, which must be downloaded from a provider's site, and which can be displayed only on computers that have both Google Earth and the downloaded files.[NOTE 19] This enables a wide range of individuals and groups—ranging from hobbyists, through community groups, to large scientific organizations—to create their own specialized electronic atlases as Google Earth overlays. The quality of these presentations ranges from crude and simple to elaborate and sophisticated. This opportunity has already been seized by many organizations to publish specialized electronic atlases, which would have been difficult, expensive, or impossible to produce in paper form.[NOTE 20]

From a societal perspective, it is worth noting that the use of KML files has made possible a measure of democratization in map publishing. Prior to the advent of digital mapping, the publication of maps and atlases was a costly and labor intensive process, which required a great deal of technical expertise. Under these circumstances, map publication was controlled by governments, wealthy individuals, and large corporations—and largely reflected and served their interests. Even with the advent of the publication of maps and atlases for the mass market in the nineteenth century, the atlas user was always the passive consumer of cartographic information, rather than its creator.

The creation of digital maps has lowered the bar for participation in the map making process. This is more true for online products like Google Earth than for older GIS programs, which are more costly and often more difficult to learn. The KML language of Google Earth applications resembles HTML, and is relatively easy to work with. There are even several applications that automatically produce KML files, without requiring users to learn the language. An example of these is *EveryTrail*, which creates KML files that can be displayed on Google Earth from trail maps that a person draws or downloads from a GPS unit.[NOTE 21]

There is something rather odd about this “democratization” of map making, which is made possible only through the efforts of very large corporations, often in conjunction with government agencies, including the military. The military-industrial complex and democracy are not usually thought of as going hand-in-hand., but in this case the marriage seems to work, at least to some extent.

How Google Earth is Our Earth

Seen in historical perspective, Google Earth is very much a response to the cartographic needs of a particular time and place. It has clearly evolved out of the Western tradition of atlas making and cartography, and it reflects that heritage in many ways. At the same time, it has adapted and developed that tradition to meet the needs of our present situation. This reworking and adaptation of the past is characteristic of most phenomena in cultural history.

That Google Earth is a creation of consumer-oriented capitalism is made most obvious by its advertisements for filling stations, restaurants, coffee shops, ATMs, and other amenities of what passes for civilization. Our reliance on the automobile is reflected in its provision of real-time traffic information, and its route finder. Google Earth itself is a prime example of our culture’s obsession with computers and technology. And its more specialized features address the wide range of needs of an increasingly complex and variegated society. As has been noted, the use of multiple layers, KML, and hyperlinks facilitates the inclusion of massive amounts of specialized information for a wide range of users.

Like conventional atlases, Google Earth addresses a variety of needs and agendas, not all of which are explicit. It supplies practical information for automobile drivers, scientists, hikers, environmentalists, historians, and others. Parts of it are mostly entertainment, much like video games, which appeal to the voyeur and explorer in us. It certainly serves the needs of its advertisers. More indirectly, it serves the interests of the United States government by being a vehicle for the distribution of government mapping, by broadcasting American culture worldwide, and as a symbol of national technological power, and prestige.

Thus, Google Earth can be seen as a mirror of “our” world, which—it should not be forgotten— is not the only possible world. Although it is an advanced product of a specific cultural tradition, the type of mapping it represents has come to be widely accepted throughout the world, and Google Earth is widely used in such places as the Middle East and East Asia. This may suggest that the world as portrayed in Google Earth is in some sense more realistic or more useful than, say, the world as represented in Aztec or early Babylonian cartography.

Possible Google Earths of the Future

Because Google Earth reflects changes in culture and technology, it or its successors will continue to evolve in response to new needs and conditions. No one can predict the future, but extrapolating from past trends, it is possible to make informed guesses about what might be in store.

On a relatively unspeculative level, we can anticipate numerous improvements in Google Earth. There is a need for expanding its coverage of high-resolution imagery, especially in third-world countries. Google Earth is full of errors, which should be corrected. These include such things as mistakes in the names and locations of places, and the failure of overlays to align correctly with the base images (which is particularly common in the case of rural roads). We can confidently expect that Google Earth will continue to add new layers and other features, and that KML applications will continue to proliferate and become more sophisticated. There is a real need to develop a better system of indexing and searching for third-party KML applications.

We can also expect Google Earth to continue to expand its coverage beyond the surface of this planet. There is already a Google Sky with an excellent Google Mars for those who wish to explore outer space. The moon has recently been added, and other celestial objects will doubtless appear. In this respect, Google Earth is following in the footsteps of the makers of celestial globes and paper atlases of other planets.

A somewhat more distant possibility is the inclusion of massive amounts of historical information. For some areas, Google Earth already includes some historical maps and satellite images taken at multiple dates. This could theoretically be greatly expanded, along the lines suggested by Gelernter in *Mirror Worlds*, to enable users to scroll through time as well as pan through space: to obtain realistic appearing images of a place as it changes through the centuries.

At this point, we start to enter the realm of speculation and science fiction. Much has been made virtual reality side of Google Earth: of its being, at least potentially, a simulacrum of the Earth, or a virtual globe. I find it difficult to draw clear distinctions between such concepts as “mirror image,” “representation,” “simulacrum” and “virtual reality.” As noted above, even in the Renaissance, atlases were regarded as a kind of virtual reality—albeit their users had to rely a lot more on their imaginations (and on separately published travel literature) than do Google Earth users to obtain their mental virtual reality experience.

Still, there is no doubt that Google Earth makes possible a kind of in-depth “virtual tourism” that printed atlases cannot deliver. As noted above, one can learn more from Google Earth about even familiar landscapes than one could without extensive exploration combined with the use of detailed maps and travel literature. And one can also use Google Earth to tour places like Somalia or North Korea, which it would be dangerous or impossible to visit. But is any of this conceptually different from using a conventional atlas? I find that the difference is more a matter of degree than of kind.

Potentially, this “virtual reality” aspect could be extended in many ways. You could use Google Earth with a virtual reality helmet to get more realistic simulations. It might then be possible to zoom in to ground level and view at least selected portions of the world on a one to one scale, and to have a virtual experience of walking across a landscape. One could even experience the earth at an even larger scale than a mile to a

mile, which was so admired by Lewis Carroll's fictional cartographers. One could, for example, take a virtual tour of the human circulatory system, or investigate a patch of ground from the point of view of an insect. It would also be possible to stimulate the brain so that the user of this advanced Google Earth could have the experience of smelling and touching in these virtual experiences. I would nonetheless argue that such applications would still be basically extensions of the idea of representation or mimesis found in a conventional atlas—provided that they restricted themselves to portraying things that actually exist.

It would be another matter if Google Earth were extended as a kind of virtual game machine—if, for example, you could use it as a platform to conduct a virtual safari, complete with simulated encounters with wildlife, thunderstorms, aliens in flying saucers, or other fictional things. Google Earth has made some rather tentative gestures towards opening itself up as a platform for virtual gaming. Most notably, a feature has recently been added to Google Earth, which allows users to conduct their own simulated moon landings. [NOTE 22] This crosses the boundary between representation and simulated reality. While this development might be regarded as analogous to an atlas of fantasy, arguably it is closer to a virtual gaming experience, a movie, or a television reality show than anything we would call cartography.

For something really different, consider the possibility of a virtual earth that actually replaces the real one. Although this takes us further into the realm of speculation and science fiction, such a development is not unthinkable. One can imagine a future in which human consciousness would be deliberately transferred to computers, as a way of escaping old age, sickness, death, or other limitations of the human condition. Alternatively, people might be involuntarily replaced by computers, as envisaged by the *Terminator* series. Or a situation could arise similar to that portrayed in the *Matrix* movies, in which human consciousness is controlled by computers, and the only world available is a digital one. Under such circumstances, the actual world might disappear or become irrelevant—thus belatedly realizing Baudrillard's fantasy. At the furthest extreme one can imagine a situation in which the physical earth is destroyed by some cosmic catastrophe, but lives on in virtual form in a computer launched into space.

Then a computerized virtual earth would become a true simulacrum: a substitute for the earth, which makes the "real" world irrelevant, even if it continues to exist. This would not necessarily involve much of a change from the present: we might not even notice the difference, and there is at least a theoretical possibility that we are already living in such a virtual world. There is some convergence between the world as displayed in digital mapping and the universe envisaged by physicists and cosmologists. Modern physics and cosmography view the universe largely in terms of mathematics, and there is thus a curious parallel between the development of physics and the mathematization of cartography. As previously noted, as cartography has become more computerized, it has become more abstract and mathematical, while at the same time achieving greater detail and verisimilitude in its results. Some serious scientists (as well as science fiction writers) have speculated that the universe as we know it may already a computer simulation. [NOTE 23] Thus, in this (to me unlikely) scenario, the most radical development of Google Earth in the direction of virtual reality would take us on a loop back to where we are right now: it would become a "mirror site" for the computer program that already underlies the universe.

Notes

1. *Google Lat-Long Blog: New and Notes by the Google Earth and Maps Team* (Feb. 11, 2008), "http://google-latlong.blogspot.com/2008/02/truly-global.html.

2. The popular literature on Google Earth is too extensive to cite here. Those interested in the scholarly literature concerning Google Earth and related applications can begin by consulting "The 'View from Nowhere'? Spatial Politics and Cultural Significance of High-Resolution Satellite Imagery," a recent themed issue of *Geoforum* 40:4 (July 2009), http://www.sciencedirect.com/science/journal/00167185. The articles in this issue, which mostly reflect a concern about developing "a critical social agenda," include extensive references to earlier literature,

3. For a basic explanation of how Google Earth works, see: http://computer.howstuffworks.com/google-earth.htm ; A more technical discussion is Avi Bar-Ze-ev, "How Google Earth [Really] Works,' http://www.realityprime.com/articles/how-google-earth-really-works.

4. Michael Agger, "The Trainspotters of Google Earth: What Happens When the Internet and Geography Collide" (posted August 25, 2006) at http://www.slate.com/id/2148229/slideshow/2148244/fs/0//entry/2148245/. For a more extensive exposition of this theme, don't miss Paul Kingsbury and John Paul Jones III, "Walter Benjamin's Dionysian Adventures on Google Earth," in the above-referenced themed issue of *Geoforum*.

5. [Stefan Geens?], "Google Earth: Atlas or Mirror World?" (April 16, 2008), http://www.ogleearth.com/2008/04/google_earth_at_1.html.

6. Abraham Ortelius, *Theatrum Orbis Terrarum* (Antverpiae: Apud Aegid. Coppenium Diesth, 1570), http://hdl.loc.gov/loc.gmd/g3200m.gct00003; Gerard De Jode, *Speculum Orbis Terrarum* (Antwerp: De Jode, 1578); Lucas Janszoon Waghenaer's *Spiegel der Seefahrt*, (Amsterdam: Waghenaer, 1589).

7. "Ce seul Livre est le monde entier, Le monde entier n'est que ce Livre." *Le Mirror du Monde, ou epitome du Theatre d'Abraham Ortelius* (Amsterdam: Zacharie Heyns, 1598), http://www.uni-mannheim.de/mateo/desbillons/atlas/seite17.html.

8. Preface to Awnsham Churchill and John Churchill *A Collection of Voyages and Travels* (4 vols.; London: 1704), lxxiii. Cited from online version in Gale Cengage Learning, *The Making of the Modern World* collection.

9. Won Hak Saeng, preface to his untitled manuscript atlas of China during the Ming Dynasty, dated 1721. Quoted on Library of Congress, Geography and Map Division, Atlas page: http://www.loc.gov/rr/geogmap/guide/gmillatl.html.

10. Lewis Carroll, *Sylvie and Bruno Concluded* (London: McMillan, 1893), 169, http://books.google.com/books?id=cTQPAAAAQAAJm.

11. Jean Baudrillard, *Simulacra and Simulation* (Ann Arbor: University Of Michigan Press, 1994), 6.

12. I know of no completely satisfactory discussion of the map-territory relationship. My epistemological position concerning the relationship between maps and the landscapes they depict follows along the general lines expounded in different ways by Gregory Bateson in *Steps to an Ecology of Mind* (San Francisco, Chandler Publishing, 1972), esp. 454-71, and by Thomas Nagel, *The View from Nowhere* (Oxford and New York: Oxford University Press, 1986). This general approach seems to be broadly compatible with the view of the nature of maps taken by Alan M. MacEachren in *How Maps Work: Representation, Visualization, and Design* (New York: Guilford Press, 1995). For a modern and intellectually sophisticated discussion of "mirroring," see computer scientist David Gelenter's readable *Mirror Worlds: Or the Day Software Puts the Universe in a Shoebox..How it Will Happen and What it Will Mean* (Oxford and New York: Oxford University Press, 1991).

13. This theme is explored by Wolf Schäfer, "Ptolemy's Revenge: A Critique of Historical Cartography," *Coordinates*, Series A (August 29, 2005), http://purl.oclc.org/coordinates/a3.htm.

14. This description is based on the section on importing data in the *Google Earth User Guide*, http://earth.google.com/userguide/v4/ug_importdata.html. But this description does not apply to small-scale maps projected on Google Earth's initial "unzoomed" screen. See Bjørn Sandvik, "KML Projections" in his *Thematic Mapping Blog* (May 27, 2009), http://blog.thematicmapping.org/2009/05/projecting-kml.html.

15. The inseparability of cartographic and non-cartographic elements in maps is a significant theme in much of the recent literature on cartography. See, particularly, Denis Wood and John Fels, *The Natures of Maps: Cartographic Constructions of the Natural World* (Chicago: University of Chicago Press, 2008), esp. 6-21, where the concepts of *paramap* and *epimap* are introduced to help explain the relationship between maps and their contexts.

16. Curiously, even the unconventional Wood and Fels see the vertical perspective as a defining characteristic of mapping. Ibid., 103-06.

17. See Kees Zandvliet, *Mapping for Money: Maps, Plans, and Topographic Paintings and Their Role in Dutch Overseas Expansion during the 16th and 17th Centuries* (Amsterdam: Batavian Lion, 1998), 210-54, and Svetlana Alpers, "The Mapping Impulse in Dutch Art," in David Woodward, ed., *Art and Cartography: Six Historical Essays* (Chicago and London: University of Chicago Press, 1987), 51-96.

18. Barbara Bartz Petchenik, “The Natural History of the Atlas: Evolution and Extinction,” in *Images of the World: The Atlas through History* (Washington, D.C.: Library of Congress, 1997), 419-433, esp. 428-31.

19. KML stands for Keyhole Markup Language (named after a company called Keyhole, which first developed what later became Google Earth). KML is an XML based language, which is somewhat like

HTML. Those interested in pursuing this subject should read Josie Wernecke, *The KML Handbook: Geographic Visualization for the Web* (Upper Saddle River, NJ: Addison-Wesley, 2009).

20. Google users should note that there is no easy way to track down KML files or the related KMZ files (which are suites of zipped KML files). Google Earth has a searchable KML "Gallery" on its layers menu, but it includes only a small proportion of the available files. Better results can be obtained by performing a conventional Google search with the keywords "KML" and "KMZ" in addition to subject or geographical keywords—although even this search technique is unreliable. For example, I blundered on important native plant and bird atlases of San Diego County, which cannot be readily uncovered by any kind of Google search (see http://www.sdnhm.org/ge_files/GE_atlas.html). These are precisely the kind of specialized scientific atlases that Google Earth makes it relatively easy to create.

21. *EveryTrail*, http://www.everytrail.com/.

22. See James Wagner, "Will O3D Get Google Back Into Virtual Worlds," *Gigaom* (May 31, 2009), http://gigaom.com/2009/05/31/will-o3d-get-google-back-into-virtual-worlds/. For virtual reality moon landings, see Kaila Kreyewski, "Google Launches Google Earth for Moon," *ISEdb* (July 21, 2009), http://www.isedb.com/db/articles/2105/1/Google-Launches-Google-Earth-for-the-Moon/Page1.html.

23. Brian Whitworth, "The Physical World as Virtual Reality," *arXiv:0801.0337v2* (revised Jan. 5, 2008), http://arxiv.org/abs/0801.0337 ; Ian O'Neill, "Our Virtual Reality Universe," *Universe Today* (Jan 15, 2008), http://www.universetoday.com/2008/01/15/our-virtual-reality-universe.

Top | MAGERT Home | Coordinates Home