# Geovisulization: new player in geoinformatic team or old cartography in a new coat?

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## Abstract

*Geovisualisation comes from information processing and displaying technology, such as cartography, geographic information science, virtual reality and visualization in scientific computer. Its appearance leads to a lot of fundamental changes in many fields, for example data exploring, making social decision and understanding how things work, and so on. It is a research focus presently. Visualization capitalizes on the strength of human perceptual abilities. The human brain has an impressive capacity for the understanding and assimilation of graphically presented information. Visualization tools provide the means to filter and explore rapidly growing quantities of spatial data, perceive patterns that may be apparent at one resolution but may otherwise remains hidden at other resolutions, offer changes in perspective that enable comprehensive views of complex landscapes, consider the relations between multiple data variables, transform surface data to simulate three dimensions and develop representations of temporally changing landscapes unlimited by constraints of a single-view map. The graphic representations that are at the centre of the visualization process stimulate visual thinking and facilitate geographic problem-solving. There is a fundamental question: does geovisualization present a new approach of visualization coming due to GIT or is it modified traditional cartographical methods in new era?*

## Abstrakt

*Stejně jako kartografie, geoinfomatika, virtuální realita a počítačová vizualizace vychází i geovizualizace z integrace technologií zpracování obrazu a zobrazovacích technik. Její zavedení vede k mnoha zásadním změnám v řadě oborů. Vizualizace je postavena na schopnostech lidského vnímání. Lidský mozek disponuje velkou kapacitou chápání a vstřebávání obrazově vyjádřených informací. Vizualizační nástroje poskytují prostředky k filtrování a objevování rychle rostoucího množství prostorových dat, odhalují odlišnosti ve zřejmých i skrytých strukturách, umožňují změny v pohledu nazírání na problémy krajiny, umožňují zdůraznit vazby mezi různorodými daty atd. Grafické reprezentace, které jsou v centru vizualoizačního procesu, stimulují visuální myšlení a usnadňují řešení grafických problémů. Existuje základní otázka: představuje geovisualizace nový vizualizační přístup, který se objevil díky nástupu GIT nebo se jedná pouze o upravené tradiční kartografické metody?*

Geographical visualization (Geovisualisation, GeoVIS) comes from information processing and displaying technology, such as cartography, geographic information science, virtual reality and visualization in scientific computer. Its appearance leads to a lot of fundamental changes in many fields, for example data exploring, making social decision and understanding how things work, and so on. It is a research focus presently.

**Visualization** capitalizes on the strength of human perceptual abilities. The human brain has an impressive capacity for the understanding and assimilation of graphically presented information. Visualization tools provide the means to filter and explore rapidly growing quantities of spatial data, perceive patterns that may be apparent at one resolution but may otherwise remains hidden at other resolutions, offer changes in perspective that enable comprehensive views of complex landscapes, consider the relations between multiple data variables, transform surface data to simulate three dimensions and develop representations of temporally changing landscapes unlimited by constraints of a single-view map. The graphic representations that are at the centre of the visualization process stimulate visual thinking and facilitate geographic problem-solving.

Current visualization technology provides a full range of hardware and techniques from static two-dimensional plots, to interactive three-dimensional images projected onto a monitor, to large screen fully immersive systems allowing the user to interact on a human scale.

An initial ICA working group on visualization was extended in 1995 to become the Commission on Visualization, then in 1999 reauthorized as the current Commission on Visualization and Virtual Environment. It took the lead in developing a comprehensive geovisualization research. There are some other current research issues mentioned in the research agenda: Collaborative Geovisulization, Web Geovisulization, Visualization-computation integration, Interface design and Cognitive or Usability issues and so on. GeoVIS has been applied to many fields, such as meteorological analysis, mine, preventing flood and so on. But it is only primary. It should have much to research and have great potential.

In 1987 a report submitted to the National Science Foundation in the US and re-published in the journal of the Association of Computing Machinery Graphics Special Interest Group (McCormick et al., 1987) took the computer graphics community by storm and introduced a wide readership to the concept of **scientific visualization** (VISC) (Fisher, Dykes, Wood 1993). They go on to state that it is „*a tool for both interpreting image data fed into a computer and for generating images for complex multidimensional data sets*“. Estimates suggest that 80 % of all digital data generated today include geospatial referencing (e.g. the geographic coordinates, address, postcode etc.) (MacEachren, Kraak 2001). The use and analyze for these data are particularly urgent. Representing geographical world is a topic paid close attention to in Cartography. The ability of computer processing enhanced day by day is the essential material base to GeoVis development. The ideas of VISC are slowly permeating the geographical and cartographic communities, particularly among those practitioners engaged in computer-based work.

## The nature of visualisation

MacEachren (1995) offers a three dimensional model of human-map interaction space that defines what might be considered prototypes for visualization and communication. The dimensions of the interaction space are defined by three continua (Fig. 1):

- from map use that is private (tailored to an individual) to public (designed for a wide audience),
- map use that is directed toward revealing unknowns (exploration) versus presenting knowns (presentation),
- map use that has high interaction versus low interaction.

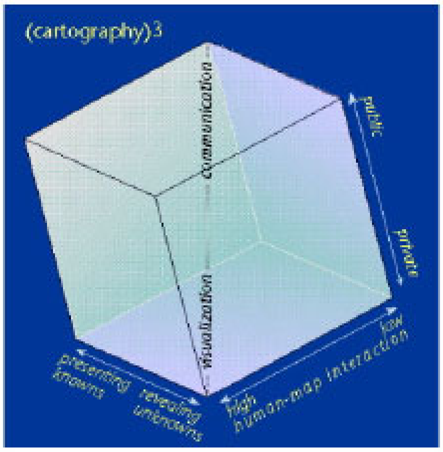


*Fig. 1 MacEachren's model of cartographic visualization as a human-map interaction space.*

While MacEachren´s model may be sufficient to depict human-map interaction, it may be a submodel of a larger set governing the total field of visualization. That activity of humans that enable them to display thoughts, data, information and even stories in images, whether it be in the mind's eye or in physical format. Intuitively one can feel that there must be basic visualization principles common to looking at a statue, a painting, a map, an interactive multimedia presentation, a graph, GIS image of a DEM and a mental vision of what a room will look like after a new coat of paint.

The continuum of visualization, from public to private use, in a geographical context, can be depicted as in figure 2. Although the categories, static images, interactive visualization and mental visualization are depicted as separate, the boundaries between them are fuzzy and the range is actually continuous and interactive. The diagram indicates the main uses of the different categories, although the boundaries are also fuzzy.

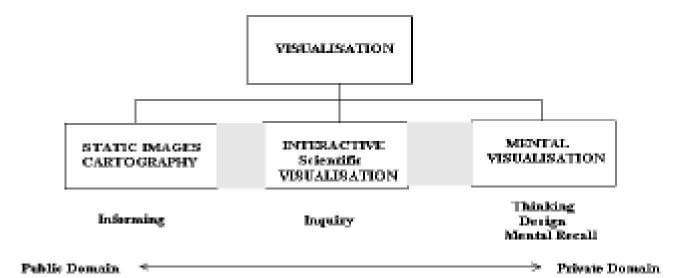


*Fig. 2 Categories of visualization.*

Visualization is the mental and physical process of graphically representing a set, or sets, of data and using the very broadband channel of human visual information flow, the human pattern recognition abilities and the human access to a rich cognitive structure for imparting hypotheses, explanations and theories pertaining to the causal processes inherent in the data. Visualization can be used to inform, to inquire or as part of the thinking process itself (MacEachren 1995, Gahegan et al. 2000, Lambrick, Van Helden, Booysen 2002).

## Cartography and visualisation

Graphical presentation of information has a long history and some of the earliest graphical presentations are maps. Cartography has had, and continues to have, an important role to play in the graphical presentation of geospatial information. Fairbairn et al. (2001) defined cartographic representation „*as the transformation that takes place when information is depicted in a way that can be perceived, encouraging the senses to exploit the spatial* *structure of the portrayal as it is interpreted. These representations are usually graphical, but may also be haptic or audible, or involve elements that mix other senses with sight*". The authors also consider the most critical issues in cartographic research to be those concerned with:

- the characteristics of the data to be handled
- the visual design and the user interface
- the representation purpose
- user interaction with dynamic representations
- the changing technology to support new forms of representation (how representations can be accessed and enhanced).

There are important **cognitive aspects** related to the visualization, perception and understanding of spatial information. The use of different information dimensions and media types that relate to different senses is useful for the understanding of spatial objects and their relations with spatial processes, and about planned situations and calculated scenarios (Bill, Dransch, Voigt 1999).

The media used to help on the perception of spatial information may have four types of **media functions** according to cognition science:

- the function of demonstration – This is achieved by using media to give a realistic picture (demonstrate the idea, object or landscape) with the support of photos, videos or virtual reality.
- the function of putting into context – The media with this function should help the user putting the detailed information into a bigger context, like an overview of the area (for spatial context), or sounds that are related to a particular area may help the user to identify and position the given information.
- the function of construction – It is related to the creation of complex mental models by the user (mental models are constructions of knowledge about information units and relationships). Abstract media of pre-prepared information is best suited for this function, such as graphs, diagrams or abstract layers.
- the function of motivation – The media with this function intends to stimulate on the user interest and attention. This can be achieved with animations, interactive objects, e.g. interactive fly-overs are a typical example for this function.

Besides the media functions, when developing a system to visualize and perceive spatial information, one should have attention to cognitive processes of:

- short term memories limited cognitive capacity,
- to increase important information,
- to avoid the overload of a single sense,
- to support double encoding if information.

Because human short term memory has the ability of keeping just seven information units at the same time, the spatial information system should not provide too much information simultaneously. Multiple representations can overcharge the human cognitive capacity, but they can also emphasize important information and improve information processing, if used in the right way (maps, pictures, sounds, videos can be used in combination to increase important information). Also, a combination of visual and sound information helps the user perception by avoiding the overload of a single sense.

The human memory can store information in a pictorial and a textual format (double encoding), so pictures in combination of written or spoken text should be used to describe information (Bill, Dransch, Voigt 1999).

**3D visualization** provides an effective way of presenting large amounts of complex information to a wide audience, including those with no GIS or mapping experience. The 3D visualization systems were designed taking into consideration cognitive principles and are able to integrate high quality mapping of the current situation, 3D representations of the future and (geo)multimedia (regarding real world information).

All communication between the readers of an image and the makers of an image now take place on a two-dimensional surface. Escaping this flatland is the essential task of 3D geovisualisation – for all the interesting worlds (physical, biological, imaginary, human) that people seek to understand are inevitably and happily multivariate in nature. Not flatlands (Tufte 1990).

Series of multimedia applications have been developed to explore different ways for providing graphical access to spatial information. It leads-on from an interactive prototype laserdisc to evaluate the effectiveness of the medium for disseminating information in the early 1980s. This subsequently led to the development of the concept of the GeoExploratorium. The concept of the GeoExploratorium was developed by Cartwright (1996, 1997a, 1997b, 1997c, 1997d, 1998) as a system for providing access to Rich Media through the use of a metaphor „suite" that could aid the building of Geographical Knowledge. Further explorations formalized how multimedia might be employed for enhancing map-delivered geographical information (Cartwright 1995, 1996a, 1996b, 2000, 2001, 2002, Cartwright, Heath 2002, Cartwright, Hunter 1995, 1996, 2001, Cartwright, Gartner, Riedl, Uhlirz 2001).

To represent the changes in the landscape, users have used for many years the combination of real world representation with virtual/future objects. The traditional ways already uses 3D, either by creating beautiful perspectives drawings and paintings that integrate the future elements with the existing ones (nowadays, also done by super imposing digital pictures) or creating physical elevation models that can be complemented with information that represents the plan. Both this approaches have a big disadvantage of lack of flexibility. It is virtually impossible to interactively change the map without having to recreate the illustration or physical model. Also the ability to show visualization of more abstract geographical information in a 3D perspective is not possible (Bodum 1999).

Furthermore, for interactive map-making processes, dealing with numerous and heterogeneous users, flexibility play a fundamental role. An example of this flexibility is the capacity of displaying the overview map but also zooming in to particular details and retrieving extra information from those details – the policy makers are interested on the overview, and the inhabitants are interested in accessing the consequences around their homes. To fly-over an area using a mosaic of aerial photographs and topographic information can give a much more realistic and dynamic view of the study area.

At the beginning of absorbing new technology, some cartographic experts carry on discussion in theory in the future. These models put forward by DiBisae (1990), MacEachren and Ganter (1990) and Taylor (1994), respectively are influential.

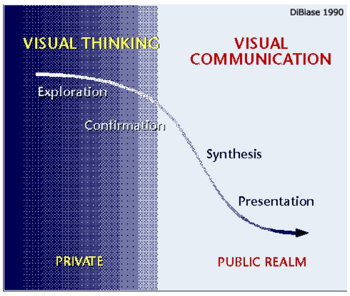


*Fig. 3 DiBisae's (1990) model of the role of maps in scientific visualization. This model focused on the need for cartographers to direct attention to the role of maps at the early (private) stages of scientific research where maps and map-based tools are used to facilitate data sifting and exploration of extremely large data sets.*

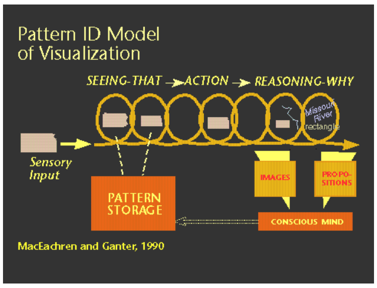


*Fig. 4 The Pattern-ID model for cartographic visualization proposed by MacEachren and Ganter (1990). Their emphasis was on developing cartographic tools that prompt pattern identification and on the potential for visualization errors (errors that are similar in nature to the Type I and Type II errors associated with traditional statistically-based hypothesis testing).*

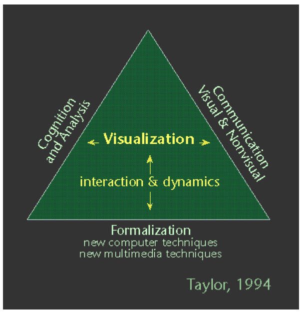


*Fig. 5 Taylor's (1994) extended and revised conception of visualization in cartography. Instead, what he argues for is a view of visualization as a distinct development in cartography, and in science in general, that will have an impact on the three major aspects of cartography that he defines as the sides of his "conceptual basis" triangle (cognition and analysis, communication, and formalism).*

Three kinds of views have the same or similar place basically, for example they all put emphasis on transmitting and analyzing functions of map, and they all pointed out that highly-interactive individual exploring vision system is the future work of cartographic research.

It can be said that **cartographic visualization** is introduced at the beginning of digital technology development. It still followed the information transmission theory of traditional cartography. Users have some interaction, but obtain the information only one side, passively mainly. Its output is still 2 or 2.5D maps. Now hardware and internet technology are developing at full speed. It extends new expression methods on one hand and need to display new geography objects on the other hand. It is further deepening result of digital technology in cartography. Contrasted with traditional map and early cartographic visualization. The emphasis of GeoVIS lies in offering one highly-interactive, dynamic visual experiment platform, which can be used to analyze, explore and work in collaboration.


*Fig. 6 Cartography visualization and geographical visualization as a part of the new communication technology.*

## 3D geovisualisation

The past decades have seen a rapid change of computer, especially technology of computer-based graphic and image processing. This technology, recently, has made it possible for visualization to be widely used in quite a lot of fields, like VISC and cartography. NSF gave a brief definition to this term: *Visualization is such a computing technique as transforming symbols into geometry graphics; it helps researchers to observe the process of simulating and computing. Visualization is a combination of image understanding and* *integrating. Visualization is a tool, used to interpret input image data and to generate images from complex multidimensional data*.

All these definitions show that computer-based visualization is an integrated system, combing the computer with users. What it aims at is to make it easy for users to understand and communicate information, just by virtue of various technologies of information encoding (mapping computer space to cognitive space). Among the objects are:

- exploration/exploitation of data and information
- enhancing understanding of concepts and processes
- gaining new (unexpected, profound) insights
- making invisible visible
- effective presentation of significant features
- quality control of simulations, measurements
- increasing scientific productivity
- medium of communication/collaboration

The development of computer graphics technologies has enabled the rise of analytical cartography and geographic visualization, where information designers now use cartographic displays for the analysis of spatially arrayed phenomena. Geographic visualization is beginning to find widespread applications throughout the discipline. As the volume of spatially referenced data continues to grow, the value and usefulness of geographic visualization methods will also increase. This new cartographic paradigm empowers map users who will be able to employ ever greater control over visualizations of a vast array of spatial phenomena. The new challenge for cartographic designers will involve the development of interactive tools and facilitative interfaces to aid map users as they explore this expanding realm of geospatial data.

## Cartographic symbolization

Cartographic symbolization is extremely diverse and based on **rules** and **proposals**. When modeling cartographic symbols, the aim should be the complete representation of graphic dependencies with a minimal amount of needed functions. In a tree structure, every graphic dependency can be represented using a root (represented object), a node (calculations, allocations, queries) and leaves (symbols and graphic attributes). Figure 7 shows the symbolization of a point symbol in a tree graph, in XML syntax and in the resulting map.

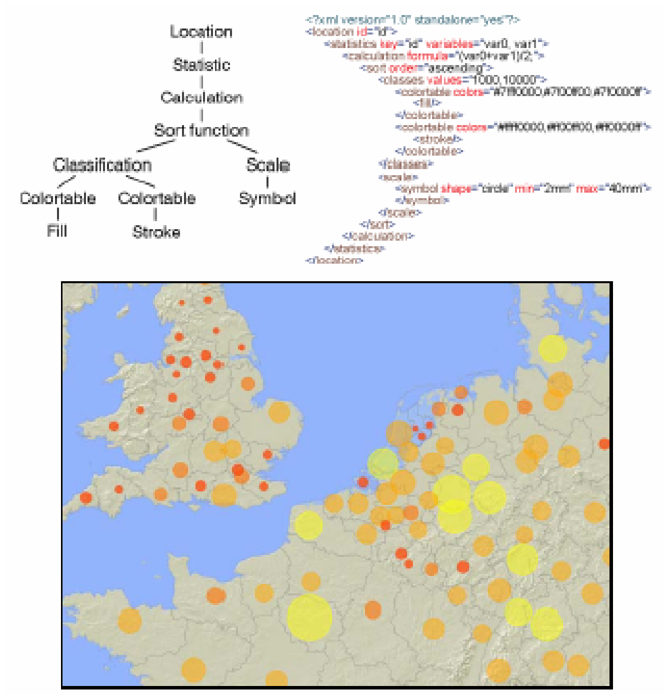


*Fig. 7 Tree structure, XML file and the according map of point symbolization.*

The values in this tree structure are passed from top down, while the nodes save temporary results. The symbolization happens while drawing. This approach is a step forward from predefined to individually designed symbols. It is extensible due to the independent objects and is capable of modeling dependencies of the symbols (e.g., location, displacement, underpass).

Today, an array of 3D display environments is on the market that blur the line between science fiction and reality. Take, for example, Actuality Systems' Perspecta, a device that addresses millions of 3D pixels in full color and looks like a giant crystal ball. Perspecta is compatible with many existing OpenGL-based 3D applications and produces 768 X 768 X 198-pixel imagery that can be inspected from various angles and magnifications — without the need for stereographic glasses.

Actuality Systems Perspecta produces 768 X 768 X 198-pixel imagery that can be manipulated for inspection from various angles and magnifications. Xenotran's XenoVision Mark III offers another new 3D display tool. It is a 3 X 4-foot table that produces three-dimensional, topographic, and full-color models in less than three minutes. The display area has a 6-inch elevation range and creates models by pushing up fabric on the table in specified points based on user-input elevation data. Image files are then projected on the protruding surface. Other companies, such as Fakespace Systems, offer more immersive environments, known as *CAVEs* (Cave Automatic Virtual Environments). Relegated to the realm of academics and scientific research during the past decade, CAVE technology is now trademarked and marketed by Fakespace for its line of virtual reality environments. These room-sized visualization tools combine multiple high-resolution, stereoscopic projectors and 3D computer graphics to create the illusion of a complete sense of presence in a virtual world. And Fakespace is not the only company developing such immersive technologies. For instance, the University of Warwick, in partnership with VR Systems UK, has created Cybersphere, a 3.5-meter hemispherical dome in which a user stands in the center and high-powered projectors combine images on the dome's surface to create a 3D virtual reality. Other companies also offer their own versions of a CAVE.

## A New Paradigm

Even though 3D visualization generally delivers a quantum increase in value, today's GIS users are mostly limited to the display of their data in 2D representations. This is not due to a lack of 3D data. 3D attributes are commonly found in GIS databases, and other forms of 3D data are readily available in both the public and private domain. Rather, the problem lies in the tools. The array of 3D spatial software on the market has swelled. Today, there are dozens of 3D tools available for photogrammetry and CAD (computer-aided design)-based terrain and feature extraction, database topology management, model building and visualization, surface texture mapping, and data analysis and decision support.

## 3D visualization in GIS

The expansion of 3D capabilities in GIS software is perhaps most readily apparent. For years, most GIS and mapping products — Intergraph GeoMedia, MapInfo Professional, Bentley MicroStation, Autdoesk Map, ESRI ArcGIS, GE Energy Smallworld GIS — have offered some form of 3D visualization capability, mostly related to draping maps/data layers over digital elevation models (DEMs) or triangular irregular networks (TINs), or to extruding building footprints based on height data. For instance, the GeoMedia Terrain tool, part of the Intergraph GeoMedia suite, includes tools for creating terrain models from elevation data, draping orthorectified imagery and maps over the model, and applying synthetic textures. It also lets users dynamically fly through the models; populate them with 3D renderings of trees, vehicles, and buildings; and correlate flythrough viewpoints with the two-dimensional GeoMedia map view. But GIS is no longer confined to such straightforward 3D visualizations. ESRI and Autodesk, in particular, are now pushing the bounds of 3D GIS with the latest release of their products. When it began shipping ArcGIS 9 in May 2004, ESRI introduced its ArcGlobe technology in a new version of the 3D Analyst extension. ArcGlobe allows users to layer any ArcGIS 2D- and 3D-supported data on a digital globe of the Earth. One can then zoom in and out on the data to visualize it from a global or local perspective. It also integrates multiresolution terrain and image data on the globe and transitions between them on the fly based on user perspective. In addition to providing the new ArcGlobe visualization environment, 3D Analyst goes a step further by enabling *analysis* within a 3D model, allowing users to, for instance, calculate steepest path, surface area, volume, aspect, line of sight. Users can also dynamically interact with and update feature and attribute data from within the 3D environment, or query data and display results with 3D symbols and polygons (see fig. 8).

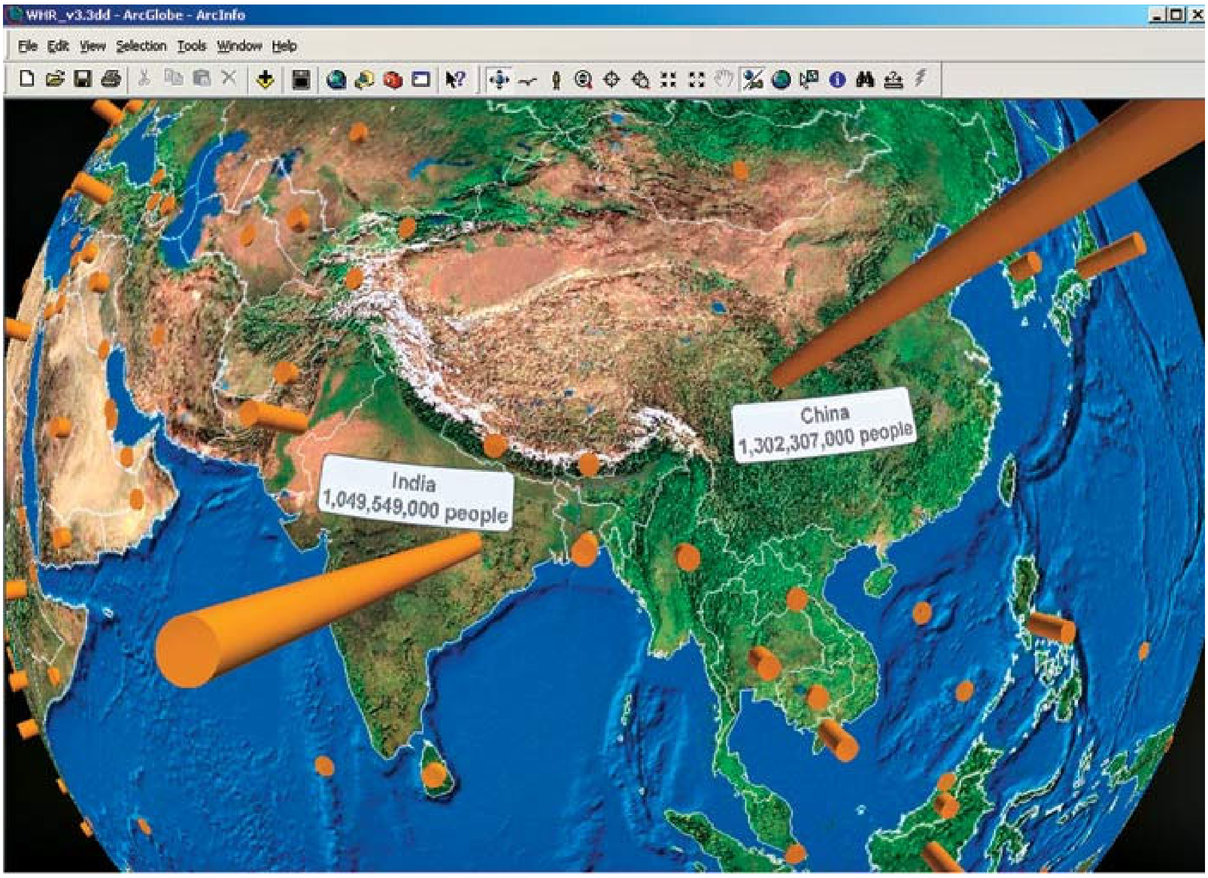


*Fig. 8 With ESRIs 3D Analyst, users can dynamically query data and display results with 3D symbols and polygons on a digital globe.*

Meanwhile, Autodesk's Map 3D 2005, released as a standalone product in April 2004 (also available as a component of Autodesk Land Desktop), provides a complete 3D environment for GIS (Autodesk Civil 3D offers similar functionality, but in an environment specific to civil engineering design for transportation and infrastructure). That is, if data in the database are three dimensional — having *x, y*, and *z* values — Map 3D treats them as such. And when used to generate 3D data from a static file, Map 3D integrates the resulting model as a database component. In other words, the product enables object-based mapping and topology for both 2D and 3D objects. Thus, if a user adds, edits, or removes data or attributes on a 3D surface, such as a TIN, the software automatically updates the surface and corresponding layers (contour lines, for example) tied to that surface — regardless of whether they are 2D or 3D. In practical terms, a user working with and manipulating data in a 2D map view may not even realize he or she is accessing or generating 3D data. However, by selecting a map rotating tool and viewing the map from an oblique angle, he or she will encounter a real-time 3D perspective view of the data (see fig. 9).

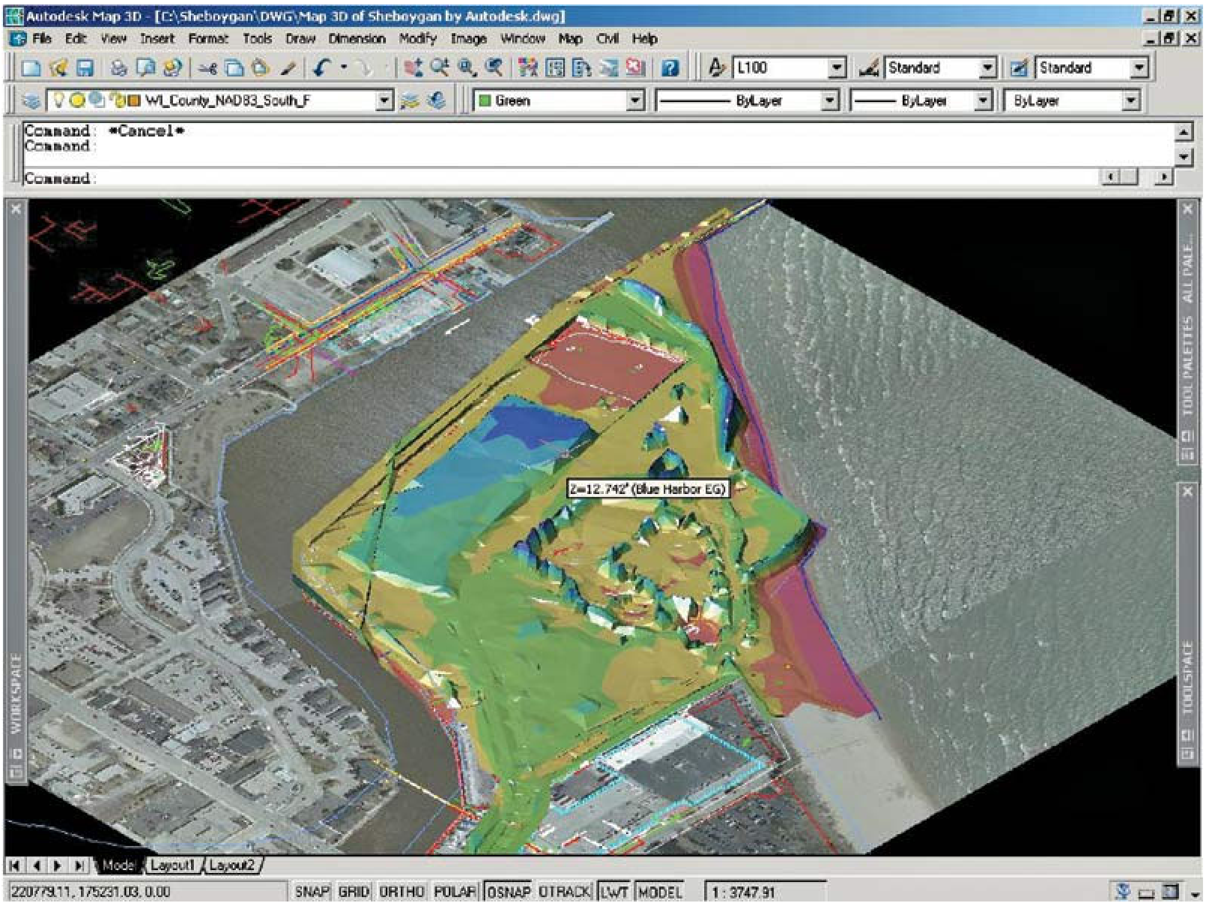


*Fig. 9 Autodesk Map 3D 2005 users can create maps and integrate data layers from a traditional 2D GIS display perspective. By viewing a map from an oblique angle, however, they expose the 3D composition of the underlying information*

Despite advancements, GIS tools can only go so far in extruding heights, applying surfaces, and creating 3D terrain models. Because the strength of GIS lies more in integrating, analyzing, and visualizing data from multiple sources, geospatial professionals interested in creating more realistic and accurate 3D representations will want to employ many other tools for feature/terrain extraction and model/scene building.

## 3D visualization in photogrammetry/image processing

Perhaps the largest category of 3D tools that users will encounter is the array of photogrammetric and image processing tools for extracting and building 3D features (buildings, roads, trees, structures) and terrain from aerial and satellite imagery. Such tools include Leica Geosystems GIS & Mapping's ERDAS IMAGINE and Leica Photogrammetry Suite; BAE Systems' SOCET SET; DAT/EM Systems International's Summit Evolution; Research Systems Inc.'s ENVI; PCI Geomatics' Geomatica; and Intergraph's Z/I Imaging Image Station.

These products offer a sophisticated set of tools that accurately model an environment. For instance, in a 3D GIS or modeling package users can place trees where they desire using a 3D symbol library, whereas using photogrammetric tools one can accurately extract the precise location, canopy size, and shape for that tree. Extracting these features is typically accomplished by drawing vector outlines of features using stereo image pairs and then registering those 3D vector drawings to the imagery.

However such photogrammetric tools are designed for use by map shops and spatial data production agencies and have a hefty price tag. Consequently, many firms specialize in generating these data for users to meet their 3D modeling needs for specific areas. In addition, many companies offer modules with a subset of photogrammetric tools for GIS users. For example, Intergraph, through synergies with its Z/I Imaging business, leverages Image Station features directly in GeoMedia via the GeoMedia Stereo Viewer. That product enables 3D stereo viewing directly within the GIS software package, providing a specific subset of photogrammetric features for creating precise 3D model data. Leica Geosystems GIS & Mapping offers a similar tool, Stereo Analyst for ArcGIS, for the ESRI environment, and DAT/EM's Stereo Capture for ArcGIS collects 3D image features directly into ArcView, ArcEditor, or ArcInfo. In addition, that company offers DAT/EM Capture, which interfaces with Autodesk and Bentley MicroStation products for 3D feature capture and editing.

Also on the cutting-edge of feature extraction/3D data creation tools for GIS is Nverse Photo from Precision Lightworks (http://www.precisionlightworks.com/). Nverse Photo is a plug-in for Autodesk VIZ and Discreet 3ds max that generates 3D city scenes from aerial photos for import into a GIS (see figure 10).


*Fig. 10 Precision Lightworks Nverse Photo is a plug-in for Autodesk VIZ or Discreet 3ds max that enables users to generate 3D city scenes and data from aerial photos without the need for stereo viewing hardware.*

3D geospatial visualization and modeling tools are essentially about providing enhanced decision support. From 3D GIS to simulation tools, the goal is to expose spatial relationships for sound analysis. Perhaps it is no surprise, then, that 3D geospatial data and models are becoming increasingly integrated with other decision-support tools, and new software products are enabling real-time streaming and distribution of 3D models across a network. There are even tools that generate their own 3D models, but also ingest additional information from complimentary platforms.

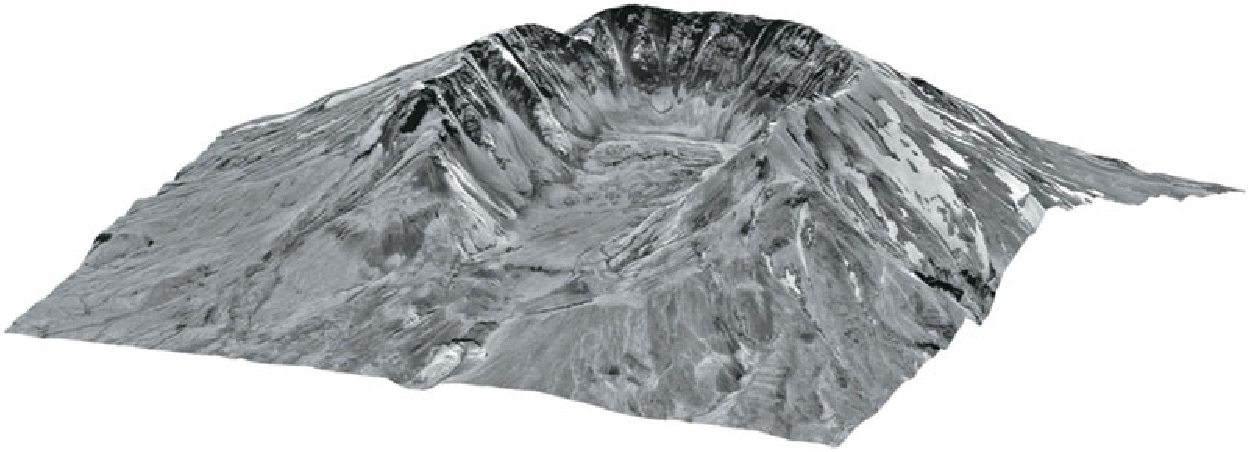

*Fig. 11 NGRAIN Corporation has developed a technology that compresses 3D models, such as this visualization of Mt. St. Helens enabling users to interact with them and modify attributes without the need for graphics acceleration hardware.*

IT Spatial's InterSCOPE, for instance, provides a visual decision-making environment to support site and region-specific operations and events. InterSCOPE's power lies in its ability to link spatial 3D models to GIS data, automatic vehicle location systems, video surveillance, communications, and more. The system, which has been installed for such security events as the World Bank/International Monetary Fund conference and political party conventions, supplies a single application from which to access and multiple data streams related to a geographic location.

Keyhole Corporation, meanwhile, is offering its Keyhole 2 product line. Keyhole 2 is a 3D Earth visualization tool that delivers data to users via the Internet using its patent-pending EarthStream technology. Users download a software tool and sign up for an annual subscription to Keyhole's data and they can access more than 12 TB of 3D spatial data. The software provides routines for customers to integrate and visualize their own GIS, CAD, and imagery data in conjunction with Keyhole's dataset. It also includes a tool for collaborating and sharing data and information over the Web. The product is available in consumer, professional, and enterprise editions.

GeoTango's GeoServNet also provides a decision-support tool for network-based 3D visualization and interactive analysis. It relies on Web services to support 3D spatial data sharing, making the tool suitable for such applications as emergency management, surveillance, and homeland security. CyberCity's TerrainView Web offers similar functionality.

And NGRAIN Corporation has developed a new technology based on the concept of volume graphics that compresses 3D models such that they can be embedded in Microsoft Word or PowerPoint documents (see fig. 11). According to the firm, users can interact with the models and modify their attributes without the need for graphics acceleration hardware.

## 3D visualization in model/scene building

Because of its unique features, Nverse Photo also straddles the line between being classified as a photogrammetric tool or 3D model/scene building package. Model building tools differ from photogrammetric technologies in that they are not primarily designed to generate 3D data, but rather are intended for creating more realistic representations of 3D features. That is, within a GIS environment, model building tools apply or drape textures on existing data — typically 3D data that has been captured with a photogrammetric tool or generated by way of GIS.

Perhaps one of the best known examples of a model/scene building tool is MultiGen-Paradigm's SiteBuilder 3D. This ArcGIS plug-in uses 3D information that is either already embedded in the GIS data or pulled from contour maps, digital elevation models, a building height database, and so forth to create the underlying 3D geometry. It then drapes an image or map over the terrain contours, thereby creating a new 3D scene (see Figure 4). It also includes a library of textures that can be applied to, for instance, building facades. With the companion ModelBuilder 3D product, one can create 3D objects for adding to a 3D scene in order to visualize a proposed development, for example. In addition to model/scene building, MultiGen SiteBuilder 3D includes tools for navigating 3D models in fly-, drive-, or walkthrough modes. It can also add environmental effects — such as time of day, clouds, or fog — and export AVI movies of models. Scenes can additionally be exported in OpenFlight, the industry standard file format for sharing and integrating 3D models into other programs.

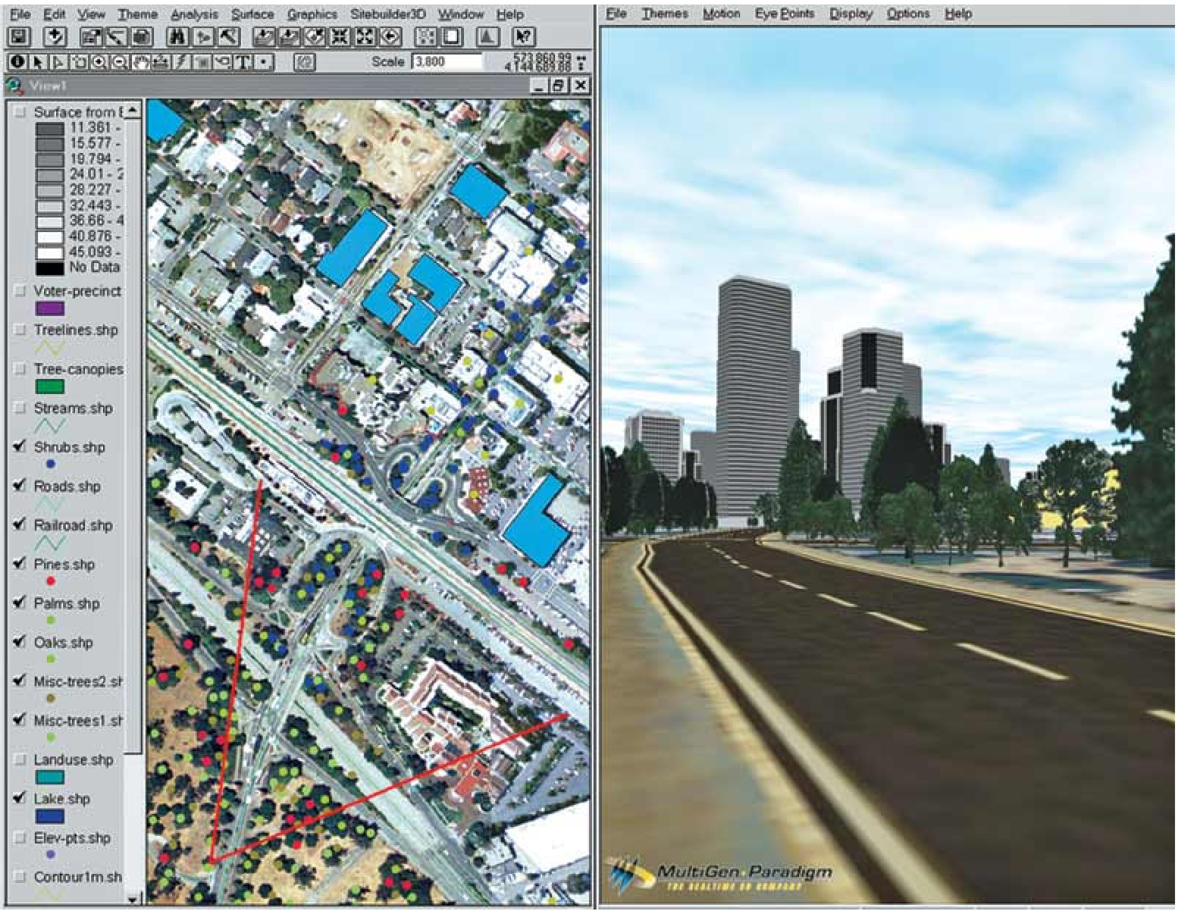


*Fig. 12 A plug-in for ArcGIS, SiteBuilder 3D uses information already embedded in the GIS data to generate 3D models. Users can display the renderings alongside 2D maps showing the direction and field of view for the visualization.*

Another product similar to SiteBuilder 3D is TerraSim's TerraTools. TerraTools, however, is a standalone product for generating 3D simulation models/scenes from cartographic source materials and databases. Using the company's GISLink any georeferences object in the scene can be linked back to the GIS data for analysis. As well, TerraTools models can be exported in OpenFlight format for integration into GIS and CAD packages. Notably, TerraSim also offers a TerraTools plug-in for BAE Systems SOCET SET, adding enhanced 3D scene generation to the photogrammetric workstation solution.

Other model/scene building tools are available from Evans and Sutherland (EP-IC ECT, Integrator), 3D Nature (Visual Nature Studio 2), CyberCity/ViewTec (CC-Modeler and TerrainView), and Viewscape3D Graphics Ltd. (Ecoviewer). Some of these and other products are targeted to specific markets, but can be employed for other applications.

Several other high-end model/scene building tools are also available — Autodesk VIZ, Discreet 3ds max, 3D Nature World Construction Set 6, and MultiGen Creator and Creator Terrain Studio. These tools, however, are intended for creating 3D scenarios and simulated environments that are not necessarily tied to geospatial data. But, because data from these programs can be exported in formats (OpenFlight, DWG, and so forth), they can also be integrated into a GIS for visualization purposes.

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