# Geographical Visualization Using Rich Media and Enhanced GIS

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**Abstract:** A current research and development program is addressing the problem of finding appropriate geographical information by developing a (geo)information realisation resource based on the concepts of the *GeoExploratorium*. It has as its main goal to provide tools for geographical knowledge building and exploring. This research examines the formulation of an initial *GeoExploratorium* prototype component to ultimately assist in military intelligence and strategic planning exercises in Townsville. The prototype enables a number of aspatial and two-dimensional and three-dimensional spatial datasets to be combined and analysed in order to formulate and explore 'what-if' intelligence strategies. Geographical Information System (GIS) and multimedia technologies underlie the *GeoExploratorium* prototype. Using both these technologies enables spatial analysis and data visualization to be undertaken, which subsequently enhances the exploration of geographical knowledge. The research examines new ways to prospect for, discover and disseminate geospatial knowledge within a military context. The paper reports on the concepts behind the design of the *GeoExploratorium* application developed for Townsville, and presents a methodology for incorporating future 'what if' scenario development and evolution and findings from the evaluation of the initial prototype.

*Keywords: Information Systems, Geographical Knowledge, Spatial Analysis, Visualization*

## 1. INTRODUCTION

The increased access to sophisticated computers by the general public has led to an awareness that resources like discrete multimedia products and their distributed counterparts on the Internet, and particularly through the use of the World Wide Web, has revolutionised the way in which information is both accessed and used. Cartographers have embraced the use of interactive multimedia, delivered via discrete or distributed means, as a method of providing products that are easily useable with 'everyday' skills, using modest computer platforms and accessible communications resources like the Web.

This paper outlines a research project that has been implemented to apply the ideas developed for a *GeoExploratorium* (Cartwright, 1997), an electronic discrete/distributed 'space' that will ultimately allow users to explore geographical intelligence using the SAGE (Specialist Advisor on Geography and the Environment) (Williams, 2002). The underlying foundation theory will be discussed, the design of a prototype described and the research and development methodologies explained. Finally, early evaluation findings will be outlined and its impact on the direction of the prototype development explained.

## 2. OVERVIEW

System requirements for the visualisation of geographic phenomena are:

- interaction, displays which allow for area-based data to be depicted (allowing the user to undertake pattern comparisons, to discover relationships;
- to 'see' geographic movement and to process and display the temporal characteristics of data) and
- a good user interface and it should be based on efficient algorithms.

Routines used in interacting with a GIS can be divided into three categories: data collection, analysis and presentation. Whilst multimedia can be used to enhance the data dissemenation to non-GIS experts, and provides assured presentation quality.

Most GIS complete these tasks through the use of map interfaces and mapping metaphors. However, there has been a trend to incorporate interactive multimedia and hypermedia with GIS, delivered discretely on hard disk or CD-ROM or via distributed means through the Internet and the World Wide Web. There has been much interest in harnessing multimedia and Geographic Information Systems to provide a better and more useable depiction of geography.

GIS and multimedia have been incorporated to produce packages in the areas of GIS education and training, improving human-computer interaction using hypermedia systems, access to new sorts of data, using hypermaps to help classify multimedia geographical information and developing new visualization techniques (Lewis, 1991). It is some years now since Lewis proposed such enhancements provided by a GIS/multimedia package, and it is now timely to explore how such a 'liaison' might function. The proposed *GeoExploratorium* involves the coupling of GIS and multimedia technologies for delivering intelligent geographical information to assist in making military and strategic decisions. The prototype will be developed for evaluation as both an intranet product and an Internet-delivered 'companion'.

## 3. THE *GEOEXPLORATORIUM*

Metaphor models form a pivotal link between learning and memory through the abstraction of relevant properties of a situation into a simplified and convenient form. In so doing they are usually dynamic and their development is effected by situational factors. Users interact with artifacts and then form mental models. Therefore interface metaphors attempt to map knowledge already held by a user group to a normal problem area (Smyth and Knott, 1994). An area or resource is needed to fully exploit the use of a set of metaphors that provide a different means of access to spatial information.

What is being explored is the application of the concept of a *GeoExploratorium*, a virtual space that would enable users to explore geographic information using different metaphors. Cartwright (1997) developed the conceptual ideas of supplying information as part of a *GeoExploratorium*: a multimedia enhanced GIS package that combines tactile, discrete and distributed multimedia components. The *GeoExploratorium* combines a number of metaphors (Cartwright and Hunter, 1999) to allow users to choose the resources and the relevant delivery method that they are most comfortable with for their specific 'discovery' and 'exploration' methodologies. The multi-metaphor resource provided by the *GeoExploratorium* enables users to choose the package or parts of a package that is most appropriate for individual tasks of geographical information exploration.

The concept of the *GeoExploratorium* can be viewed in a similar way to the Geographer's Desktop (Egenhofer and Richards, 1993), but would not be as immersive as the Virtual GIS ROOM (Neves *et al.*, 1995) and some of the

access devices would work in a similar way to the Covent Garden Hypermap (Parsons, 1992). However, it does differ in the use of a different metaphor set and the links to external resources that provide 'reality links'. As well as providing access to multimedia, hypermedia and interactive maps, the *GeoExploratorium* would provide links to other 'world wide' resources. These links to reality are shown in Figure 1.
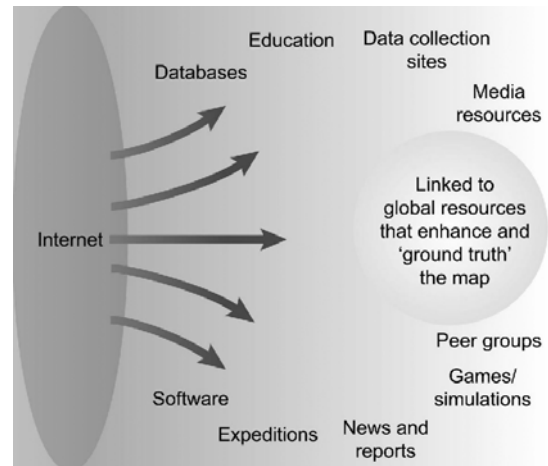


**Figure 1. Links to reality via the Internet**

The Townsville case study is being used as a test bed for applying these concepts, and providing access to a range of 'Rich Media' elements that can assist with decision-making. The results from the evaluation of the Townsville prototype will guide the formulation of strategies for using the other *GeoExploratorium* metaphors (Cartwright and Hunter, 1999). The case study will be 'built' around information collected and data assembled for the centre of Townsville (see Figure 2). This area was chosen as it contains elements that will be tested using *'what if'* scenarios that will assess strategic information provision related to the built environment; transport facilities (land, sea and air) and natural features.

A '*GeoExploratorium* Guide' will be included in the prototype. It will assist users in selecting the appropriate metaphors to use and find the required information through links to distributed resources. The *GeoExploratorium* Guide will be 'built' with respect to the attributes proposed for the SAGE (Williams, 2002) and will link to discrete and on-line resources that comprise the *GeoExploratorium*.

The metaphor set to be used in the *GeoExploratorium* was proposed by Cartwright 1997) and its purpose is to provide component parts of the *GeoExploratorium*. It provides complementary ways to understand and comprehend geographic information using

multimedia. The metaphors were originally conceived and developed with discrete multimedia products as 'targets', but the concept can be extended to distributed multimedia.



**Figure 2. Study area**

## 4. DEVELOPMENT OF THE *GEOEXPLORATORIUM*

The *GeoExploratorium* metaphor set includes the Storyteller, the Navigator, the Guide, the Sage, the Data Store, the Fact Book, the Gameplayer, the Theatre and the Toolbox (Cartwright, 1999). It is argued that the combination of these metaphors, when used with the map metaphor would provide the means to deliver the contents of the *GeoExploratorium* using multimedia components.

The GeoExploratorium could provide the means for geographic exploration and discovery and it would offer both discrete and distributed resources and be hosted by a virtual Exploratorium guide that could use intelligent agents in a geospatial context as discussed by (Rodrigues et al. 1995) Specifically through the application of the SAGE to explain virtual and real intelligence spaces.

## 5. APPLICATION – GEOGRAPHIC INTELLIGENCE

Technological advances in computer systems over the past two decades have provided mapmakers and land resource managers with capabilities to perform increasingly sophisticated mapping and geographic analysis functions. For much of this period development has followed two distinct streams; one concerned with automating the map-making process and favoured by the traditional mapping organisations, and one focusing on environmental analysis and land planning functions preferred by regional planners, asset and facilities managers, etc.

We have now reached the time when we now have a range of technologies and these technologies are enabling the fusion of the two trends. However, the World Wide Web, the *e*-phenomena, and society's desire to be better informed now mean that the simple fusion of the existing capabilities from those two traditional trends is no longer adequate. We now need to know far more about our environment than ever before and we need to make decisions far more quickly than ever before. We need to embrace the concept of a geospatial information infrastructure and geographic intelligence.

### 5.1. Specialist Adviser on geography and the Environment – a SAGE

The availability and access to geographic and environmental information is growing at a staggering pace; a pace which far outstrips our ability to use it credibly for, not only the planning and conduct of operations and routine activities, but for strategically more important purposes such as strategic national development, homeland defence and security, and so on. We now need to consider the concept of designing and creating *virtual advisers* or artificial agents. One such concept might be that of a Specialist Adviser on Geography and the Environment – a SAGE. However, if we embrace the concept of an artificial agent then we need to investigate the scope and context of the *world* in which the SAGE would function.

It seems intuitive that the SAGE would need to know about the past. The SAGE would need to have available a comprehensive knowledge of the sciences, technologies and disciplines of the past and the implications to present databases and archives. The SAGE would also need to know about previous studies and reviews, previous initiatives and activities; and the SAGE should have access to documentaries, narratives, histories, and so on. In addition, it seems that the SAGE would need access to a plethora of policy guidance documents, agreements and memoranda.

The SAGE needs access to the nation's geospatial information infrastructure (the ASDI) via accredited portals, etc. The knowledge base needs also to include white papers, and a comprehensive range of scientific and technical sources suitable to both naïve and expert users. Furthermore, it seems that the SAGE needs a visionary component. The knowledge and vision of domain experts needs to be elicited and this information organised into capability development strategies. Such strategies need to be cognisant of acquisition processes and scope the near, mid and long terms acquisition programs of an

organisation. Overall, the concept for the SAGE can be shown in the illustration below.
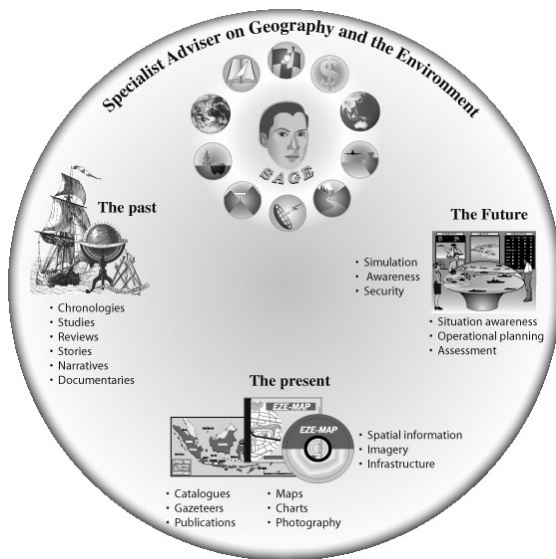


**Figure 3. Concept of the SAGE (Specialist Adviser on Geography and the Environment) (Williams, 2002)**

## 6. PROTOTYPE – TOWNSVILLE GEOKNOWLEDGE PROJECT

The Townsville prototype is being developed to incorporate both multimedia and GIS elements, accessed through the appropriate use of metaphors, in the first instance incorporating Cartwright's Sage metaphor with William's SAGE concept. The prototype has been designed to be delivered via a World Wide Web browser and requiring minimal plug-ins – for *Flash* and *QuickTime* movies. As this is being used as a testbed for the GeoExploratorium two access interfaces have been provided as part of the initial interface, a 'map' of information resources and a 3D *Information Landscape* that the user can move through. The remaining section of this paper concentrates specifically on the 3D *Information Landscape* interface (See Figure 4).

The VRML components of the *Information Landscape* are designed to provide a World where users can browse and 'walk' through the information access 'space', that is a virtual terrain built on information availability, rather that physical or human geographical information. Similar concepts have been applied for accessing news stories (Sparciano, 1997) and building DTMs of 'likeness' of news stories that can be analysed through standard GIS applications (Fabrikant, 2003). Testing will evaluate whether users prefer the traditional 2D map interface or the *Information Landscape*.
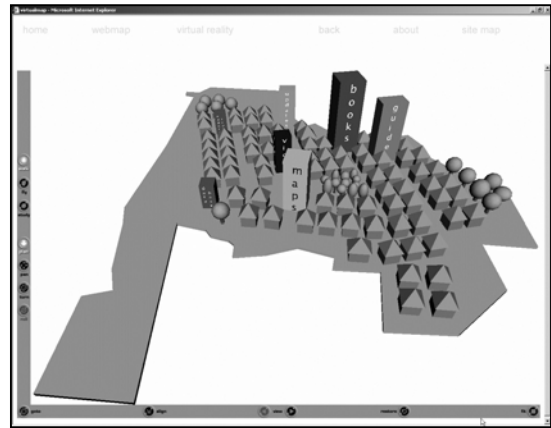


**Figure 4. 3D *Information landscape***

Using the *Information Landscape* users can move about the 'terrain' and move into areas of (information) interest to 'prospect' for geographical information related to pre-determined areas of need, or merely browse through the space. The VRML World contains links to information that includes videos and audio that are able to be activated by clicking on the image (which is an active 'running' video) (Figure 5) or audio logo that appear on the 'walls' of areas of information availability 'buildings'. The appropriateness of this method and whether users access this information in an intuitive way will be evaluated as part of this research program.
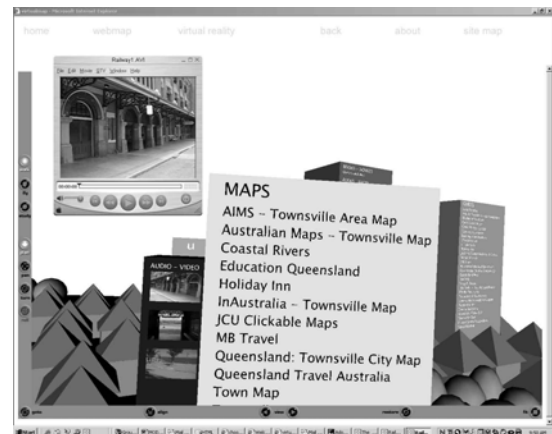


**Figure 5. VRML World links – URLs and audio files**

This information access method provides access to current information. But, to best empower users to make better decisions a hybrid product will be developed which will allow users to 'slide' between current, archival and projected information using a '*Temporal Event Continuum*' slider control. This information 'dial-up' method will be developed parallel to the population of the *Information Landscape* using *what if* scenarios. This will be realised by users accessing information through the *GeoExploratorium*

'portal', and in the initial stage of prototype development only the Sage metaphor will be employed. Users will then be able to slide along the *Temporal Event Continuum* vector and choose information related to where it occurs at a certain time, present, past or future. This concept is illustrated in Figure 6.
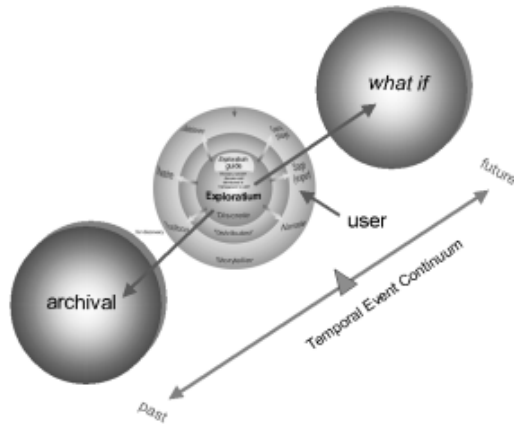


**Figure 6. GeoExploratorium and Temporal Event Continuum**

*What if* scenarios will add GIS functionality to the *GeoExploratorium*, and the planned method for achieving this is outlined in the following section.

## 7. ADDING GIS FUNCTIONALITY TO THE *GEOEXPLORATORIUM* – WHAT IF SCENARIOS

GIS and multimedia technologies underlying the *GeoExploratorium* prototype enable both spatial analysis of data visualisation to be undertaken. Specifically, the *GeoExploratorium* prototype component conceptualised in this paper focuses on datasets acquired for Townsville to ultimately explore *what if* intelligence strategies. In recent time *what if* scenarios have been developed and tested in the context of urban and regional strategic planning both nationally (Pettit, Pullar and Stimson 2002) and internationally (Landis 1994; Klosterman 1999).

If *what if* scenario modelling can assist in making better urban and regional planning decisions then inductively we explore the possibility of *what if* scenario modelling assisting in making better decision in a military intelligence and strategic planning context. Modelling of 'what if' scenarios involves the formulation and evaluation of a number scenarios based upon a number of input parameters, and specified constraints and opportunities. A control scenario is typically developed first and is commonly referred to as a *business as usual* scenario (Landis 2001; Pettit and Pullar 2001). The remaining scenarios can be used to measure the deviation from the *business as usual* scenario in order to visualize and analyse the effects particular military intelligence or strategic planning decisions may have. This enables likely future outcomes of decisions to be more fully explored in order to assist in making critical strategic decisions. The *what if* scenario tool will initially be develop using a simple linear trend projection technique. It is envisaged that future work will see the development of a *what if* scenario tools that uses a micro-modelling approach, such as the SLEUTH cellular automaton model developed by Clarke & Gaydos (1998) to predict future urban growth patterns.

This paper has put forth a conceptual model (Figure 9) for developing a *what if* scenario tool as a component to a *GeoExploratorium* prototype. By using the *GeoExploratium* to access *what if* scenarios it is believed this will enhance the usability of geospatial decision support system technology for users who do not have particular expertise in driving traditional GIS tools. This is because the interface to the *what if* scenario component will be developed with a soft multimedia front end which is easily navigatible by users who are not literate with complex geospatial technologies.

## 8. CONCLUSIONS

The use of a GIS incorporating multimedia devices as a tool for the visualisation of geographical relationships can be seen as perhaps one of the ways in which spatial decision support (where decisions are based on the evaluation and consideration of data which is spatially unique and geographically referenced) can be effectively made available. The hardware and software developments of both multimedia and GIS have now reached a stage where the technological issues have been resolved. The linking of such powerful systems allow for the presentation of spatial data, which is spatially accurate and timely and presented in such a way that it supports the decision-making process

The addition of multimedia elements to a GIS can improve the user's visualisation of reality when it is displayed graphically as three-space data and time. As spatial data about natural and cultural objects change over time, in terms of position, weighting and dominance, it is important that the display of the quantitative information (the information, when given an accurate four-dimensional position can be termed geographical information) correctly gives the user a narrative of space and time capturing the essence of what is being depicted and hence aids visualisation.

This paper has discussed the use of multimedia with GIS. The coupling of GIS and multimedia technology through the application of the GeoExploratorium provides a different approach to the provision and analysis of geographical information, through the use of data and Rich Media elements, making for a powerful geographical information visualization tool for assisting in strategic decision-making.

The initial project will run until December 2003. Funding obtained from the Defence Science and Technology Organisation will be used to configure ongoing research in geographical visualization

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