

# DIGITAL EARTH VISUALIZATION AND WEB-INTERFACE CAPABILITIES UTILIZING 3-D GEOBROWSER TECHNOLOGY

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**KEY WORDS:** Three-dimensional, Visualization, Virtual Reality, Global-Environment-Databases, Archiving, Rendering, Web based, GIS

## ABSTRACT:

Since the early days of the first Earth monitoring satellite launches, the ability to distribute these important data resources to the world community has been especially challenging. This chronic shortcoming of the remote sensing community is increasingly viewed as a tragic situation for those addressing the rapid decline in ecosystem goods and services around the globe. Under CEOS and the new ad hoc GEO community, a host of organizational and architectural constructs are being addressed; however, the unwieldy nature of large intergovernmental organizations prohibits effective implementation scenarios that require environments where rapid and innovative technological implementation can be pursued. 3-D Geobrowsers, an important enabling technology originally identified with the Digital Earth community, are rapidly proving their value in the access and distribution of remote sensing and GIS information. Developments of network spans, as proof-of-concept, are beginning to be implemented within the global network. Priority remote sensing based applications using the Geobrowser technologies will begin to foster collaboration or alliances, and critical alignment with the leading intergovernmental bodies will become paramount to manifest the promise of global observation systems and the goals of the Millennium Declaration. An international Digital Earth group of technology developers has been collaborating through a series of workshops on the fulfillment of 3-D Geobrowser for operational implementation towards the ubiquitous and free access and web-based distribution technology for all nations and their citizens.

## 1. INTRODUCTION

### 1.1 A Community with Potential

A community that arose from the US NASA's now defunct Digital Earth initiative has been achieving steady advances in the development of highly intuitive and engaging three-dimensional visualization graphic-user-interfaces (GUIs), commonly referred to as 3-D Geobrowsers. This loose confederation of like-minded developers has as a common goal the implementation of web-based browsers that will directly access vast archives of global environmental databases (including both GIS and remote sensing) and render these information resources through Earth-based virtual reality software tool kits. Under the nascent mantle of the International Society for Digital Earth, multinational members of the development community have been negotiating on the operational principles of 3-D Geobrowsers from the perspectives of a broad user community and the interoperability protocols of the growing global geo-spatial infrastructure. This paper provides an overview of the advances in 3-D Geobrowsers, leading members in the development community, the global design considerations for implementation, and the major challenges facing ubiquitous operations via the internet.

### 1.2 US Satellite Archives

With the launch of ERTS 1 (subsequently renamed Landsat 1) in July of 1972, a new era dawned on the community of nations with the unprecedented synoptic and regular collection of remotely sensed land surface data. Over thirty years ago, government agencies, industry, and academia began addressing the challenges presented by the Landsat series for collecting, processing, archiving, and distributing these unparalleled data sets for applications on mapping, monitoring, and modeling the Earth's surface and life support systems.

The USGS EROS Data Center was created along side the Landsat satellite program to meet the archiving challenges of Landsat data. While providing the basic archiving functions and the operating protocols (which have witnessed many changes over the years under different administrations) the EROS Data Center has not been able to provide global satellite coverage to the nations of the world. Instead, as a result of shifting government priorities and policy conflicts as commercialization and new sensor systems have been launched, a patchwork of coverage and depth of coverage has emerged. By the end of the 20<sup>th</sup> century government scientists were exploring ways to address these obvious shortcomings and to incorporate, if possible, international strategies to align the suite of sensor systems to create a truly international global observing system.

### 1.3 Intergovernmental Systems

Under the leadership of CEOS a litany of thematic target sensor observation systems have become part of a continuing agenda (e.g., IGOS, ITOS, et cetera (CEOS, 2004)). While progress can be demonstrated in the deliberations of the rolling agenda, operations and applications remain restricted to the domains of large government, industry, or academic centers. Motivated in part by the Millennium Declaration and the series of "findings" from the 1992 World Summit for Sustainable Development, a new initiative was announced at last July's Earth Observation Summit. The ad hoc intergovernmental Group on Earth Observations (GEO) was launched to develop a 10-year implementation plan to address the need for timely, high-quality, long-term, global information as a basis for sound decision making and to enable the continuous monitoring of the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement environmental treaty obligations. The plan will be presented at the third Earth Observation Summit in February of 2005 (GEO, 2004). Based

on existing conditions, it is not likely that these deliberations will yield major solutions to the current lack of access and distribution of global satellite data and associated information to all nations and their citizens. However, there is ample evidence that as the GEO community improves their formatting and access policies, 3-D Geobrowsers will be in position to facilitate the free and equal distribution and application of these vast global archives.

## 2. THREE-DIMENSIONAL GEOBROWSERS

### 2.1 Field of Dreams

In March of 2000, a meeting of the Digital Earth Interagency Working Committee was convened to review the status and progress of 3-D visualization technologies in generating virtual reality simulations for the Earth. A significant cross section of industrial, governmental, and academic systems was debuted at this milestone event. This community of supporters easily accepted the spinning globe technologies as the iconic symbol for Digital Earth. This amplified the vision presented by former Vice President Al Gore in his historic speech. At that time in the evolution of the Digital Earth initiative there was only a general agreement as to what should be expected of these 3-D Geobrowsers (although they were simply given the term of Digital Earth visualization). Performance specifications were relegated to the catchall for open systems and interoperability protocols set out in the Digital Earth Reference Model (DERM). As a result, progress of the dozen or so systems continued with minimal attention to standards for performance. Each system developer operated more or less under the philosophy of “if we built it, people will come and use it.”

### 2.2. African GIS Realities

In November of 2001, at the 5<sup>th</sup> African GIS Conference in Nairobi, Kenya, the United Nations Environment Programme contracted with one of the leading Geobrowser developers, Keyhole Technology, Inc. to provide the first international display of an operational Geobrowser. This system streamed data from globally distributed servers to provide a stunning display of global satellite coverage of the Earth’s surface including the overlay of database resources upon the spherical tessellation of a virtual globe, Figure 1. As the audience included government and industry leaders from around the globe, the impact of this milestone presentation cannot be overstated.



Figure 1. First international debut of 3-D Geobrowser.

### 2.3. Chinese Interest Continue Legacy

The Chinese Academy of Sciences (CAS) picked up the Digital Earth mantle and founded the International Symposium on Digital Earth series. In addition to their stalwart support for an international collaboration on Digital Earth technologies, the Chinese began a robust engagement with national, provincial, and municipal Digital Earth projects. Until 2002, however, the application of 3-D Geobrowsers was limited to visualization demonstration. In December of that year, the CAS hosted the 1<sup>st</sup> International Society for Digital Earth workshop on 3-D Geobrowsers. This meeting brought together representatives from many of the Geobrowser development teams including Japan and the US. Consensus was developed among the participants to create a draft document titled “Mandate for Digital Earth Geobrowsers: Status and Recommendations.”

### 2.4 US Developers Convene

A second workshop was hosted by the National Center for Geographic Information and Analysis at Santa Barbara in March 2003. A significant portion of the US Geobrowser community was in attendance to further the development of the draft document and to define criteria for the performance goals likely to address the majority of the user community requirements. Emphasis was placed upon alignment with the ongoing protocols as well as the standards undergoing definition from the ISO, OGC, and GSDI communities (Foresman, et al, 2003). Many current developments in Geobrowser implementation were created from the partnerships formed at this workshop.

### 2.5 First Round Requirements

Initial goals for Geobrowser performance, or the functional user requirements, were identified as a result of these two workshops, Table 1. These results were considered, however, to be both preliminary and high-altitude design guidance. Further experience with networked and semi-operations systems would be required to fine tune the details of architectural specifications useful to current and future Geobrowser developers. These activities have been perused in part by a strong desire to curtail the proliferation of stand-alone systems that end up detracting, not contributing, to the improved cooperative understanding and management of the Earth’s resources.

Function or Element	Description of Function or Element
Platform/Server Hardware	the hardware requirements for the server side software operating in conjunction with processors, memory, and other systems components
Operating System	the operating systems that the software must run on
3-D Rendering	the methods and algorithms applied to the graphic presentation of three-dimensional objects determining the performance and hence functional limits
Tessellation	the method used to enable dynamic, local to global, seamless display of framework data
Client/Server	the architectural strategy for hardware and operating systems performance across a network
Data Type	the capacity to handle different types of and formatted data
Volumetric Rendering	the methods and flexibility for addressing three-dimensional displays and models for volumetric applications

Time Series	the strategy and algorithms for integrating time series data link to the viewers domain
Internet	the performance characteristics for operating on multiple and distributed databases
Client Hardware	the assumptions for the user's system
Multi-Layer Capability	the methods for handling multiple layers of raster and vector data formats with flexibility for transparency and defining display priorities
GIS Identification	the identification of appropriate and priority databases with all associated attributes
Entity Selection	the ability to address any entity identified and manage the use of the entity for additional operations, such as query, search, access, and download
Multiple Connections	the ability to link simultaneously with distributed data resources
Data Compression	the methods applied to manage data compression in accordance with web standards

Table 1. Functions or elements needed for 3-D Geobrowsers.

### 3. OPERATIONAL ALLIANCES

#### 3.1 Geobrowser Workshops

It has been stated that a good cross section of the Geobrowser community has been involved with the workshops on these tessellation-visualization systems since 2000. The 3<sup>rd</sup> Digital Earth Geobrowser workshop will be held in Cairns, Australia in early July of this year to begin defining the operational links between Geobrowsers and satellite archives. This represents an important evolutionary step in the advance from stand-alone systems, or national systems into network systems. The objective is to apply the basic global spatial data infrastructure for the transmittal of data among servers at two or more international nodes. At each node, one or more Geobrowsers will be installed to display and access the archival holdings of satellite data and associated GIS databases. This Alliance span proof-of-concept is meant to benefit not only the current constituent users of each node but to increase the global coverage for the access and distribution of satellite data and derivative products, Figure 2.

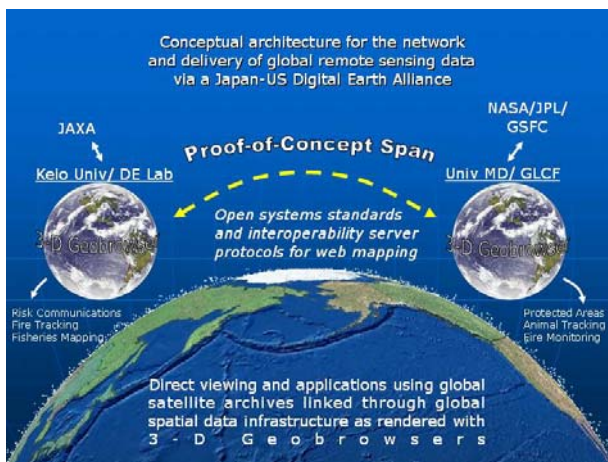


Figure 2. Conceptual architecture for Japan-US web span.

#### 3.2 Geobrowser Network Applications

While access and distribution currently define the major challenges to ubiquitous utilization of Earth observation data outside specialized technology domains, the key for expanding the use and acceptance of remotely sensed data and information is in fostering priority and broad-based

applications. These applications will help form the nexus as a series of operational alliances are formed over the coming months. For this objective the following priority applications have been identified as having value to a wide range of scientists and citizens and the potential to stimulate further exploration:

- Protected Areas – includes Heritage Sites, Hots Spots, and areas with significant biodiversity assets or other cultural significance. Key user community includes UNESCO, UNEP, IUCN, EarthVoice, Conservation International, NatureServe, et cetera.
- Animal Tracking – includes the location and tracking of avian, land, and aquatic animals with special significance to educational curricula and science projects. Key user community is NOAA, NASA, research and academic institutions.
- Forest Fires – includes the mapping and monitoring of fires at global, national, regional, and local scales. Implicit is the definition and categorization of forested vegetation and the integration of real or near-real time satellite data. Key user communities include international forest watch programs, governments, fire centers, and citizens of proximity.
- Risk Communication – includes locations, planning and siting, and activity monitoring for categories of risk. Risks range from the handling of high-level radioactive waste to disaster reduction issues of famine, flood, and other natural phenomena. Key users include international agencies associated with the International Disaster Reduction Secretariat, national governments, industry, academia, and most importantly the broad base of citizens.

#### 3.3 Convergence with GEO and CEOS

One of the challenges facing the pioneers and promoters of 3-D Geobrowsers has been the disconnect between the momentum inherent in these technologically elegant solutions and the inertia inherent to the conventional international and intergovernmental organizations, including the newly formed ad hoc GEO. While commercial stand-alone Geobrowsers have demonstrated success in commercial markets, there is no equivalent success among the bureaucracies created by the international organizations whose collective capacity far outweighs the technical and financial resources of the independent commercial firms. In fact, it is the bureaucratic atmosphere that consistently obstructs the creation of operational systems to deliver data to the citizenry. It is mandatory that these conditions experience a dramatic paradigm shift if the CEOS and GEO communities are serious about delivering large volumes of remote sensing data to the citizens of the world. It is equally incumbent upon the Digital Earth Geobrowser community to deliver proof-of-concept operational network spans (a link between two centers) to the members of these international associations. It is hoped that over the coming months, the efficacy of these network access and distribution solutions using Geobrowsers will generate increased alliances that will fully converge with the goals and objectives of the GEO and CEOS communities.

### 4. NEXT STEPS AND SUMMARY

#### 4.1 Proof-of-Concept

Currently, there exist a few profitable private companies that are providing 3-D Geobrowsers services to private firms and government agencies. In addition, a number of organizations

have purchased Geobrowser tool kits to begin building in-house systems for the visual display of three-dimensional projections of their data. Though these systems generally feature Earth-related data, they are being increasingly applied to planetary bodies as well. A variety of developments can be traced to the original set of Geobrowsers that debuted at the 2000 Digital Earth meeting. What has been missing in this increasingly diverse set of development efforts is the creation of global standards for the performance and operational protocols that would allow for ubiquitous and free access of information about the planet and its conditions to all citizens. The series of Digital Earth workshops represents the only documented forum dedicated to this important goal. This effort could be viewed as a precursor for sustainable development decision support systems.

#### **4.2 Paramount Actions**

As we recognize the increasingly rapid pace of change on the surface of the Earth, including the ocean and marine environments, we must conclude that the rates of change and the impact on social, economic, and environmental systems require immediate and widespread collaborative action. However, without a common framework from which to address actions, the approach to understanding conditions, ameliorating negative impacts, and managing our life support systems will not be obtained in time. The next steps, aligned with the Millennium Declaration, are to connect all nations and their citizens with a common view of the planet. In addition to this common view is the access and distribution of applications and tools to help form consensus on priority actions at local and regional levels. All of these actions must be fully inculcated into the education foundation. As such, the motivation for convergence of operational 3-D Geobrowsers with the CEOS and GEO community should be of the highest level.

#### **4.3 Summary**

No single technology represents a panacea for the world's problems and challenges. Likewise, there appears to be no single view on the conditions and trends of the planet. Early and enhanced implementation of 3-D Geobrowsers integrated with the world's networks of scientists, governments, industry, and citizenry may prove to be a keystone element in driving sustainable development objectives to the front pages of tomorrow's agendas. At present, we witness scientific and engineering-valid metrics that demonstrate the Digital Earth approach is no longer visionary but imminently implementable. The question begged is to what extent and at what pace will the leading organizations and associations embrace this Digital Earth reality.

### **5. REFERENCES**

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