The Issues Related to Geoinformation In Developing Countries

By

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1.0 Geoinformation

21st century is the century of information. Societies using information efficiently and wisely will be more prosperous than others. It is already a fact that half of the employment throughout the world is on information technology services and 80% of those are spatially related, i.e. geographic (Fig. 1)

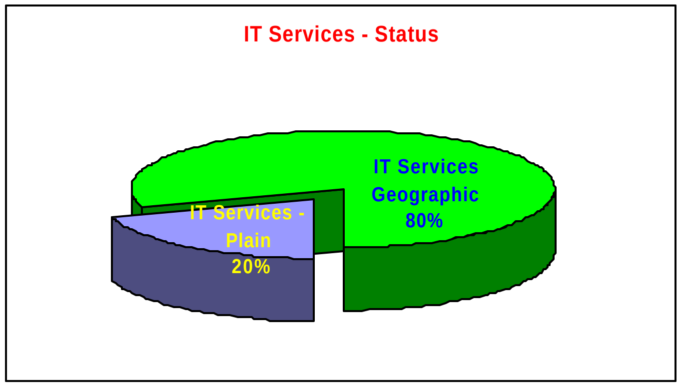

Figure 1. It Services and Geoinformation

Geoinformation consists of digital spatial data in form of maps (point – line – area data), images (aerial photos, satellite images), elevations (digital elevation models) and associated attributes (alphanumeric data related to points, lines, areas, objects). Geoinformation is key for planning and management of cities, land use, planning and management of utilities and resources, multipurpose cadastre, e-government, e-municipality, e-commerce, all other spatially related information (Konecny, 2003).

Correct understanding, design and implementation of geoinformation are very crucial for the success of projects in this field. The first fundamental point is to understand that geoinformation is developed by using the disciplines of geomatics engineering: geodesy / GPS / CORS, surveying and mapping, remote sensing / satellite mapping, photogrammetry / orthophoto, cartography, Geographic Information Systems (GIS). Secondly, the efficient use of geoinformation is possible by means of proper hardware and software: computers, servers, internet, databases and GIS software, etc. Finally, for the activities mentioned above and use of geoinformation, it is required to have skilled and competent manpower and organization. So, the consideration of these three main factors is key for the success of any geoinformation mission.

Over the years, we have had plenty of observations regarding geoinformation activities of numerous agencies, witnessing a lot failure, especially in developing countries. We have made comprehensive assessment based on our observations and pointed out some common misconceptions:

1. Geodatabase: the concept of georeferenced, accurate, attributed and complete geodatabase is not correctly understood. It is very common to see organizations still investing on CAD products and non-rectified images thinking that it is the eventual Geodatabase !...
2. Hardware / Software: owing to great job HW/SW vendors do, many organizations look at geoinformation activities nothing more than buying HW/SW, especially geoinformation software. They heavily invest on HW/SW and get shocked when they cannot due anything due to lack of data.

3. Organization / Manpower: it is also very common to see organizations heavily investing on data and HW/SW without the presence of proper organizations and qualified manpower, contributing poor database establishment, selection of improper HW/SW, getting wrong consultants / contractors and eventually failure of geoinformation mission.

As far as geoinformation and applications are concerned, the sky is the limit. It is known that undeniable progress in technology will make location based information (geoinformation) access critical. In this respect, the vision and research of people are the transition to 3D geoinformation, integrate geoinformation with cell phones and GPS, and create virtual cities, virtual homes, virtual stores, virtual tours, walkthroughs, instant access to services and locations, real time traffic control, vehicle and personal tracking, etc.

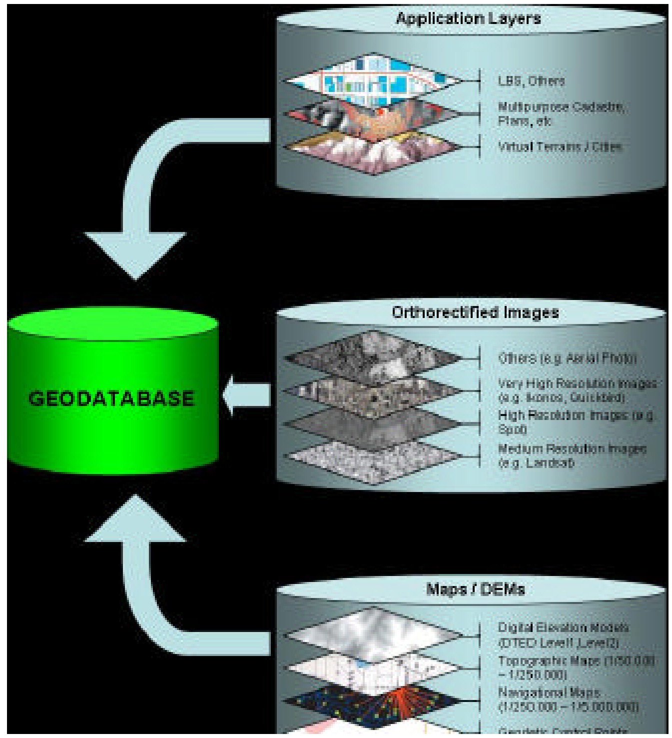

Figure 2. Geodatabase and major categories

2.0 Geodatabases

As indicated above, the foundation of geoinformation is geodatabase, which mainly consists of the following three major categories of graphical data and associated attributes (Figure 2):

1) Maps / DEMs
2) Orthorectified Images
3) Application layers

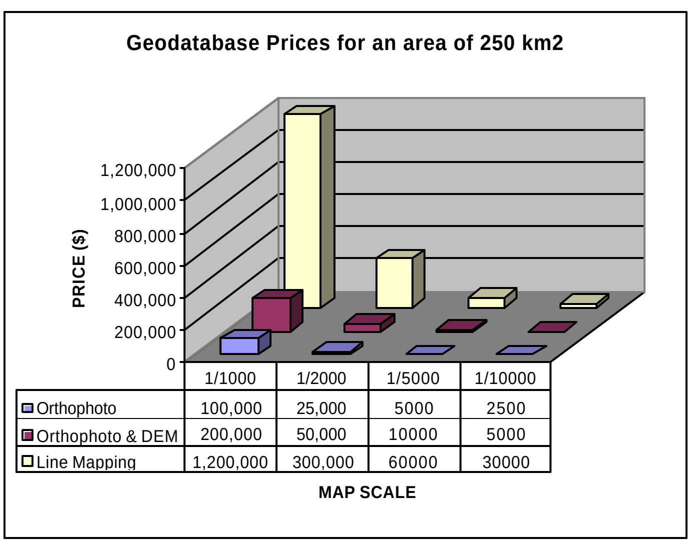

Figure 3. Geodatabase development costs

The development of geodatabase is the most costly and time consuming part of geoinformation projects. Fortunately, there are modern approaches offering more economical and timely solutions such as orthophoto, very high-resolution satellite images, etc. Figure 3 shows the cost of different approaches for the compilation of graphical data belonging to geodatabases. A complete coverage of geodatabases can be found in Mondello et. Al. (2004).

Needles to say that geoinformation and geodatabase imply correct geographic positions of graphical data according to standard format, accuracy and contents (Henderson, 2004). They need to be referenced

a well-defined geodetic network adopted nationwide, even globally.
Otherwise it will be very difficult, even impossible, to integrate different type of data, causing data mismatch as shown in Figure 4, an example in the heart of Europe.

Each major component of geodatabases is briefly discussed below.

Figure 4. An example to data mismatch

2.1 Geodetic Network

The reference for geoinformation is geodetic coordinates defined in a national system. In the past, every country introduced their own datum and established their own national network based on the technology of its time, mainly by measuring distance and angles. These networks yielded 10-100 ppm relative accuracies. With the introduction of modern positioning techniques such as Global Positioning System (GPS), it is now possible to establish geodetic positions to 0.01 – 1.0 ppm accuracy level. Thus, geodetic control points required for mapping and geodetic terrestrial surveys can be carried out by GPS techniques more economically and accurately. It is also common practice now to use the global datum known as International Terrestrial Reference Frame of 2000 (ITRF-2000) with GRS80 ellipsoid, i.e. a = 6378137.0 m and f = 1/ 298.257222101

As an example; with our support, Deputy Ministry of Land and Surveys (DMLS), Ministry of Municipal and Rural Affairs of Saudi Arabia established a new geodetic network consisting of 659 stations, all based on ITRF-2000 datum (DMLS, 2005). The network accuracy achieved is better than 1.0 cm in position. Saudi Arabia also established 13 CORS collecting GPS observations continuously. The establishment of additional CORS for IRTK applications nationwide is under progress.

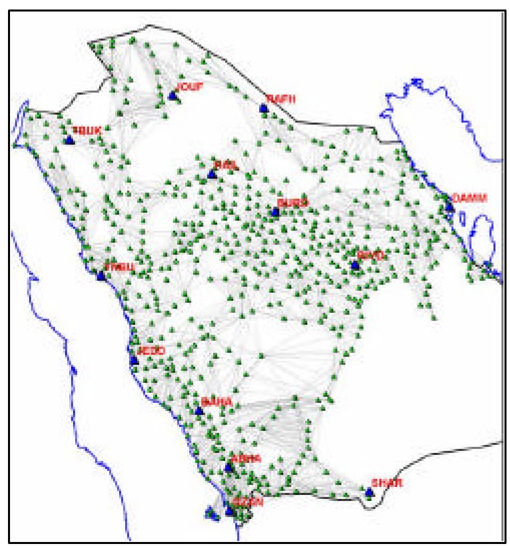

Figure 5. Saudi geodetic network and CORS in ITRF-2000 datum

2.2 Digital Elevation Models (DEMs)

Geodatabase is never complete without the topography represented by Digital Elevation Models (DEMs). Through DEMs, the topography can be represented as contours, slope, aspect, and relief. Amongst others, DEMs are excellent tools for planning, transportation, design of Engineering structures, orthorectifying aerial photos and satellite images.

2.3 Topographic / Cadastral Maps

Traditional topographic and cadastral maps in digital form constitute the 1st category in geodatabases. Traditionally these maps are usually in raster and/or CAD format lacking any intelligence. They are transferred into geodatabase after being brought into a seamless structure through proper georegistration, edge-matching and mosaicking.

The updating of topographic maps is costly and time consuming as can be seen in Figure 3. The ongoing large scale mapping projects of DMLS in Saudi Arabia (see Fig. 6) covers about 200,000 km2 at a cost of over 100 Million Dollars. The completion of these projects may take 5-8 years. Therefore, the role of topographic maps in geodatabases decrease in favor of rectified images.

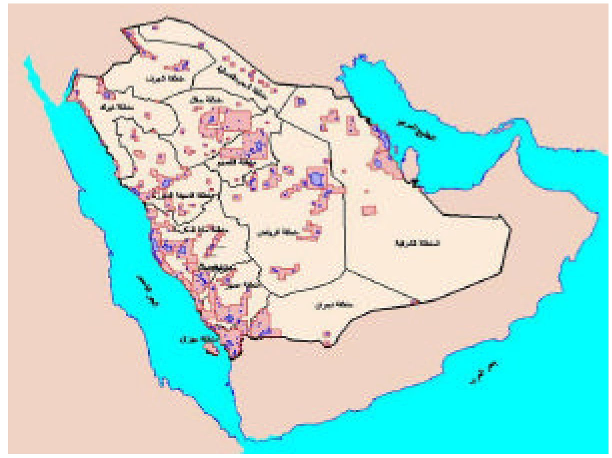

Figure 6. Aerial photography and mapping in Saudi Arabia

2.4 Orthorectified Images

With the advance of digital and satellite technologies, images offered excellent opportunities as far as geoinformation graphical data is concerned. Production of orthophotos and orthorectified satellite images are much faster and much more economical compared to topographic mapping as illustrated in Figure 3. Besides, images reveal much more information compared to line mapping.

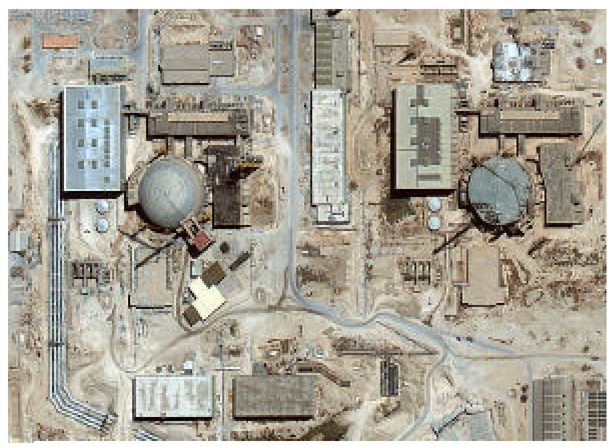

Figure 7. 0.6 m resolution QuickBird

The resolution of aerial photographs range from 0.05 m to 10m, whereas that of satellite images range from 0.6 m to 1 km (jacobsen, 2004). The highest resolution satellite image commercially available at the present (June 2005) is QuickBird with 0.6 m resolution (Figure 7).

Using proper processing techniques together with proper DEMs and Ground Control Points (GCPs), one can achieve a geometric accuracy of better than 1.5 pixels. Hence, the scale of orthophotos can be as large as 1/500 and the scale of orthorectified QuickBird image is as large as 1/4,000 scale.

Satellite mapping using Ikonos (1m resolution) and QuickBird was very effectively used in Saudi Arabia. Saudi Telecom Company (STC) urgently needed basemaps for planning and customer services. As there exists very few up-to-date basemaps in the country, STC decided to use satellite mapping with the consideration of time constraint and economy. In 2 years, all the urban areas of the country amounting to 100,000 km2 was covered by orthorectified Ikonos and QuickBird images, which have positional accuracy of better than 1.5 m and 1.0 m respectively.

Then, the rest of the country was covered by LANDSAT-7 images. The total cost of satellite mapping is about 5 Million Dollars, which is less than 10% of line mapping.

2.5 Application Layers

It is common acceptance that basemaps and images are the most fundamental layers of any geodatabase. At the top of these layers, others can develop the layers of their specialization and applications such as planning, transportation, environment, utilities, e-government, e-municipality, e-commerce and so on.

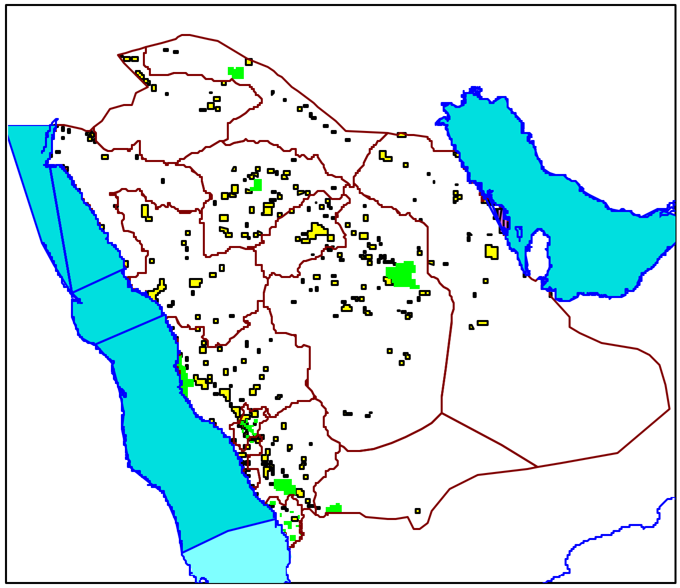

Figure 8. Ikonos and QuickBird coverage of STC Project

3.0 Future Trends

This section briefly discusses the future trends in geoinformation, which will directly or indirectly affect every human being (Eren, 2005).

CORS with Network Approach

The future trend in geodetic positioning is to have accurate coordinates in seconds at any place and any time. The best technology for this practice is use of Network Real Time Kinematic Solutions (NRTK) using GPS technologies together with area corrections and/ or virtual / pseudo stations (Wubbena et. Al., 2001). This technique is the improved version of classical RTK techniques which are used for ranges up to 10 km. In case of NRTK, the network approach is used and GPS positioning error sources, especially atmospheric errors, are modeled. Thus, RTK range is significantly increased up to 70 km.

For NRTK applications, Continuously Operating Reference Stations (CORS) are established at proper spacing, like every 100 - 150 km, covering the entire geodatabase area. The coordinates can be determined very quickly and economically without any need for static base stations. Thus, any time, the geodetic surveys can be carried out very efficiently, including surveys for geodetic control, planimetry, utilities and so on.

Intelligent GIS Maps and Real-Time Orthophoto / Rectified VHRS Images

Conventional CAD mapping will gradually leave its role to more intelligent graphical data known as GIS ready graphical data (see Figure 9).

As far as image maps are concerned, the future trend is to produce them in real-time using the archives of DEMs and GCPs, thus responding geoinformation requirements in most timely manner.

Figure 9 . GIS map

Web-Based Portal GIS

The most affective use of geodatabases and geoinformation in different platforms is the use of web-based technologies by establishing web-based portals. Thus the data sharing will also be very affective. Web-based portal GIS will especially be very affective for government agencies, e-government, e-municipality and e-commerce applications. An example to web-based portal GIS is illustrated in Figure 10.

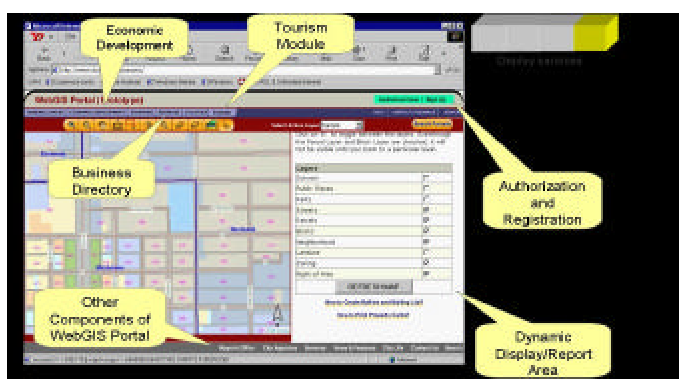

Figure 10. Web-GIS Portal – Future Directions

Location Based Services (LBS)

Location Based Services (LBS) are getting more and more popular with visitors and customers to locate their point of interest, both textually and visually, especially via mobile phones. Throughout the world, it is estimated that about 20% of mobile customers use LBS amounting to about 200 million customers.

LBS by mobile require telecommunication infrastructure and geodatabase consisting of main features sought by customers such as bancomat, events, movies, restaurants and bars, taxi, hotels, pharmacies, etc. Users can select by landmark, by vicinity, address and route description, and so on. An example to LBS is shown in Figure 11.

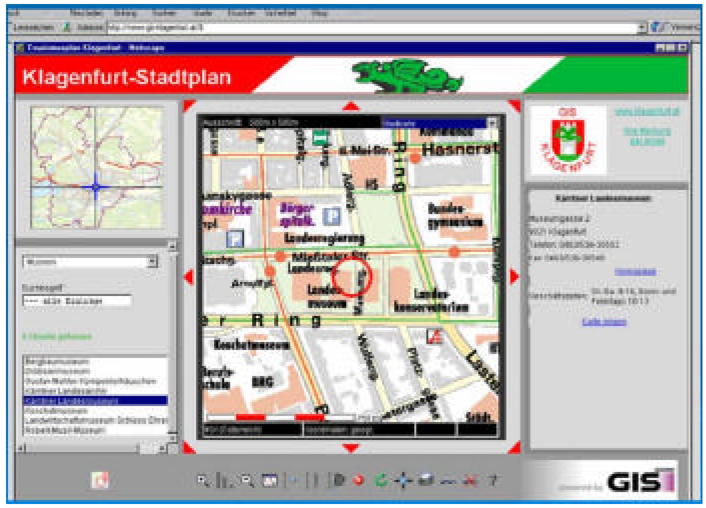

Figure 11. LBS using map

Vehicle Tracking - AVL

Another excellent application of geoinformation is navigation / vehicle tracking systems (VTS). VTS is a product that will permit users to track their vehicles and consequently provide protection and efficiency of both the vehicle and the driver at a very low cost.

Every organization needs to keep track of its assets -especially moving ones for safety, control, efficiency and many other reasons. GPS technology provides the accuracy, effectiveness and affordability for such systems. GPS based Fleet Management Systems (FMS) and vehicle tracking systems have thus become the real-life business implementations of a strategic technology. The principles of VTS can be seen in (Figure 12.

Vehicles carry valuable and time-sensitive cargoes. Vehicles are valuable themselves. Whether you haul your own cargo or someone else's, the knowledge that where your vehicle is, what it is doing and when it is due to arrive at its destination is indispensable for your business. And, of course, it is not just a matter of freight transportation. Tracking an ambulance and guiding it through busy streets or slow moving freeways can literally be a matter of life and death. From police patrols to yachting teams in the high seas, from school services to express delivery vans, vehicles in almost every imaginable situation can be an effective area of implementation for fleet management.

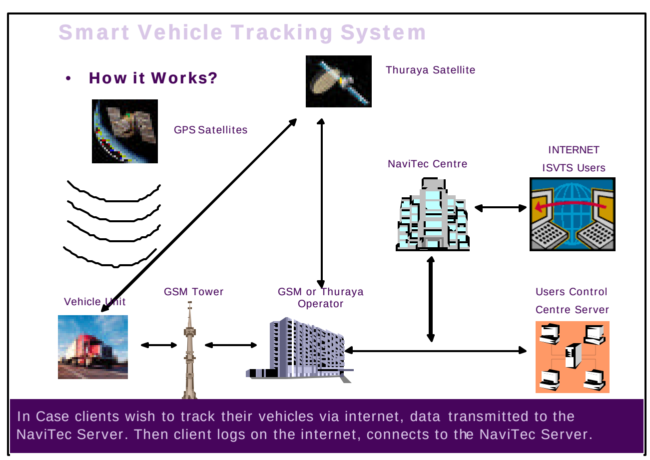

Figure 12. VTS Principles

Virtual Cities

The technology has advanced so much that photorealistic graphics and thus virtual cities will be realities in the near future. Thus, amongst others, it will be possible to have

- Walkthroughs
- Helicopter level visualization
- Flight level visualization
- Administration and management of cities by virtual representations

There is one particularly important project the author is involved, which uses the principles of virtual cities. This project is about the administration, management and better services to visitors of the holy cities of Makkah and Madinah using virtual cities approach.

Each year Hajj presents an unequaled experience; it is at once a very personal exploration of one's faith even as one is in the presence of nearly two million people yearly from every corner of the world. The vast number of attendance and the profound spiritual aspect of Hajj require the development of unique technologies that will minimize logistic concerns. Development of the Virtual Hajj technology is not only beneficial to the millions of Muslims around the world, but it is also beneficial for the authorities in the Holy Cities to access the same data (at a higher priority level) for communication and planning.

The basis of the Virtual Hajj is a faithful creation of the Holy Cities. At first the city will be viewable as a whole, to be navigated smoothly. Geo Tech Group has developed a software package known as GTVS for such applications. The GTVS engine has been developed in-house to become one of the finest technologies available for real-time display of terrain on even mid-range personal computers (Figures 13 and 14).

This virtual model of Makkah has been prepared with a QuickBird Satellite Image and allows for the navigation of data at 60 frames per second even on a three year old laptop.

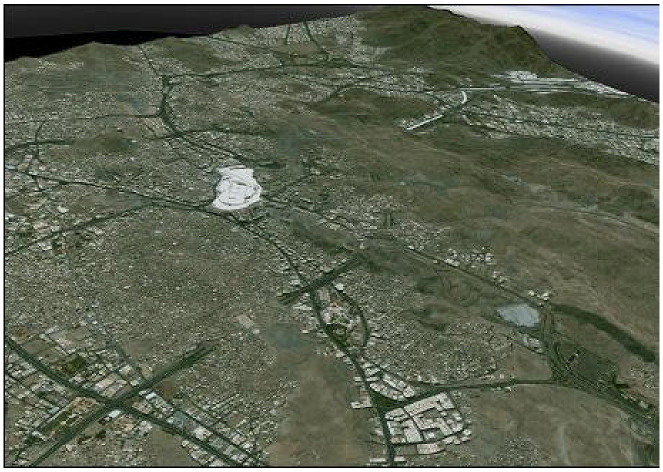

Figure 13. GTVS Package using QuickBird images

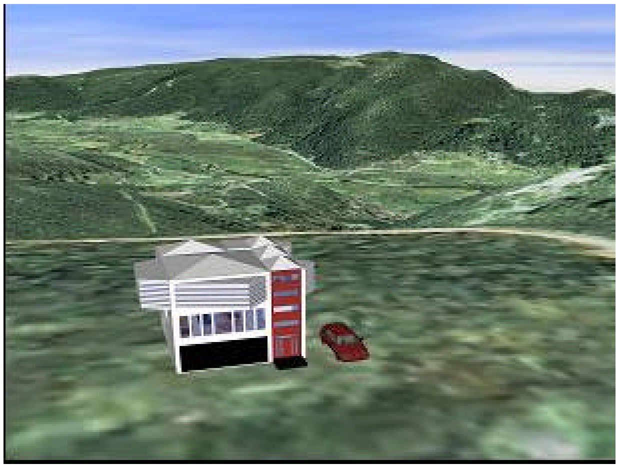

Figure 14. GTVS Package using IKONOS images

Beyond the terrain render of the city, the GTVS technology has been expanded to become Virtual City 2.0. This expansion makes it possible to create structures on-the-fly from GIS data. Nearly 2,000 buildings per second can be created from scratch.

Virtual City 2.0 can generate virtual cities very quickly. But if it is desired for a structure to be detailed and even make it possible to walk inside, this is also possible. Thus GTC's technology can take the user instantly from a citywide perspective to a level where they are walking around and even inside buildings (where required). The user may even see other users as 3D humans and interact via text chat messages.

Beyond the visual representation of the Holy Cities, it will be possible through the Virtual Hajj technology to access a variety of information: accommodations, travel routes, historical background and so forth. To provide access to a wide variety of data, Virtual City 2.0 technology is fused with GeoView, a rapid and flexible GIS engine. This powerful engine will be presented with a unique interface.

Access to information presents only half of the story, sharing and analyzing the data is necessary as well. A user accessing the Virtual Hajj environment must not only be informed of accommodations, but be able to reserve a room, rent a car and so forth. They may even want to ask questions to a local representative online. Virtual City 2.0 is fully connected via an internet server, any user who enters the Virtual Hajj environment will be able to connect to other users, to service providers and to local guides. As this online environment allows users from all across the globe to walk the streets of Makkah, Madinah, ask questions to locals, reserve rooms or rides, government officials can log in with special privileges, monitor the requirements and use the Virtual Hajj for planning.

For the Virtual Hajj project to be successful it must reach a wide range of users. Our Virtual City 2.0 technology creates compact terrain data without sacrificing quality, it also supports OpenGL, thus making it compatible with nearly every modern PC. Thus it will be possible for the Virtual Hajj to be distributed online via a moderate download and be set up and running very quickly on nearly every PC with an online connection.

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