

MULTIROLE GEOSPATIAL DATA INFRASTRUCTURE

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Abstract

The Geographic Institute of the Army is the cartographic production institution responsible for the base map of Portugal at a scale of 1:25k, which is used in most geoinformation systems for civilian and military purposes, and derived products such as aeronautical itinerary charts, digital terrain models, Vector Smart Map Level 1 product maintenance, and the Multinational Geospatial Coproduction Program from several areas of the Globe.

This paper describes a Geospatial Data Infrastructure (GDI), an integrated and operational system to provide the Portuguese Armed Forces, in particular the Portuguese Army, the ability to visualize, explore and analyse digital geographic information with real time navigation based on GPS equipments. The GDI supports operational missions allowing a Common Picture of the Battlespace, peacekeeping operations and can also supports the civilian community. The GDI is described around five main components: (1) A Geospatial Database that contains all the related information; (2) A GIS Web-based portal of IGeoE (IGeoE-SIG); (3) An Army Intranet system with classified information (SIG-Ex); (4) Web services available to be used with COTS or tailored software; and (5) A stand-alone application to be used on portable devices to support disconnected operation.

INTRODUCTION

The Portuguese Army Geographic Institute (IGeoE – Instituto Geográfico do Exército, www.igeoe.pt) is the entity responsible for the production and updating of Portugal's basic cartography, i.e., the Portugal Military Map on a scale of 1:25.000, as well other derived maps widely used by the civilian community. IGeoE supports operational missions related to geographic information and training of the National Forces deployed in several Theatres of Operations (including Afghanistan, Iraq, Bosnia, Kosovo and East Timor, for example). Besides being a provider of a considerable amount of digital geospatial information (DGI) in Portugal, IGeoE is also responsible for other derived products such as aeronautical itinerary charts, digital terrain models, Vector Smart Map Level 1 product maintenance, and the Multinational Geospatial Co-production Program (MGCP) from several areas of the Globe, which allows Portugal to fully address its international responsibilities in this area, particularly on a NATO and EU level.

IGeoE is an institution certified by the International Standard Organization ISO 9001:2005 (Quality), ISO 14001:2005 (Environment) and 18001:1999 (Hygiene and Health Protection at Work). It is the first Portuguese public institute to have received simultaneously these important certifications.

With the increase of bandwidth and the appearing of multiple geospatial data and services over the Internet, the potentiality of distribution, exploitation and combination of DGI became "a must" for geospatial information producers. It was conceived, researched and developed a Geospatial Data Infrastructure (GDI), which was based on the enterprise database produced; allowing that, in this context, its information became available to general public (citizenship information), to the Armed Forces (classified information). The GDI presents several benefits, such as the digital study of the battlefield, the Intelligence Preparation of the Battlefield (IPB) [Marine Corps, 1998], continuous cycle with the objective of keeping updated information

¹ in Proceedings of the 26th Annual ESRI International User Conference (San Diego, USA) 2006.

about the terrain, enemy, meteorology and friendly forces; integrate the Military Decision Processes; and allow *Internet, Intranet* and stand-alone application access, evaluating and trying to achieve the several requirements of the different actors involved.

As a producer of Digital Geographic Information, one of the endeavours of IGeoE stands for making available to the general public and the military community, a system based on simple browsers, services or applications, that allow visualization and exploitation of the data produced or obtained, to publicity it and increase their use to the maximum extent, using network, digital radio transmission and other, in a pervasive, ubiquitous, distributed and centric services environment [Espinoza 2002].

GEOSPATIAL DATA INFRASTRUCTURE

The Geospatial Data Infrastructure (GDI), as suggested in Figure 1, is an integrated and operational system to provide society in general, the military community, and in particular the Portuguese Army with the ability to visualize, explore and analyse digital geospatial data, with, eventually, real time navigation based on GPS equipments, to be used in operational missions allowing a Common Picture of the Battlespace, peace keeping and humanitarian operations based on five main technological components:

- 1) The Geographic Database (GDB), that contains the information produced by IGeoE and also others obtained under international agreements;
- 2) A geographic information portal over the Internet (IGeoE-SIG, www.igeoe.pt/igeoesig/igeoesig.asp) with citizenship information;
- 3) An Army and Armed Forces Intranet system with classified information (SIG-Ex);
- 4) Web services to be used with commercial-off-the-shelf (COTS) or tailored software and civilian visualizers;
- 5) Stand-alone application to support disconnect navigation and exploration of digital information on the field, using portable devices.

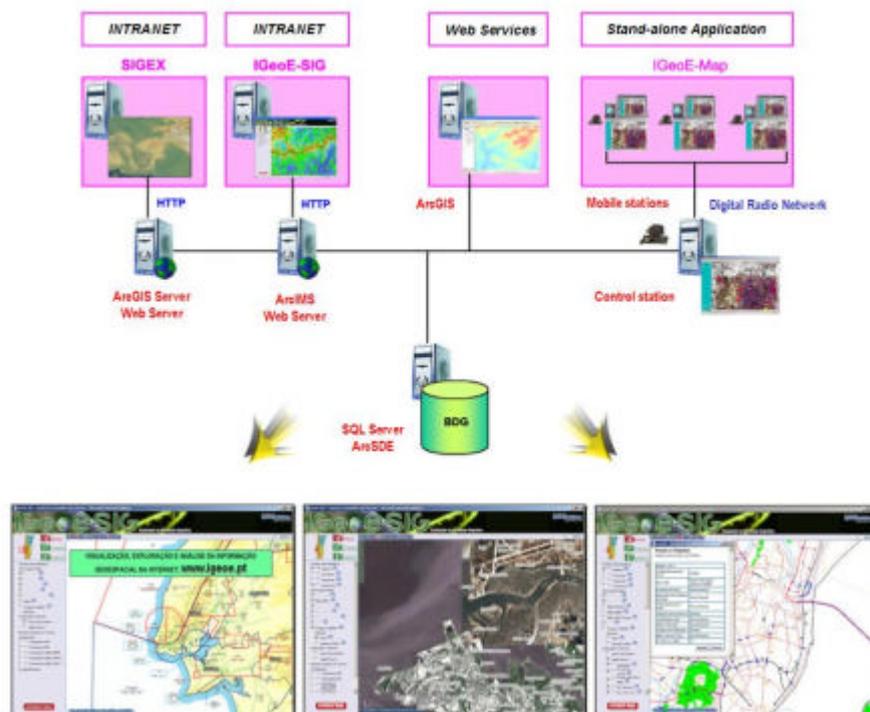


Figure 1 – IGeoE Geospatial Data Infrastructure.

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To achieve the implementation of such a system, it was decided to use COTS applications, namely from Microsoft and ESRI companies. From the data base point of view, the GDB is supported by *ArcSDE* and *SQLServer* database server. *ArcIMS* was the map server, used to support the publication and access the maps through Web browsers. The publication of data throughout the military private *Intranet*, in operational and administrative units is being granted by the use of *ArcGIS Server*. Web services available in *Intranet* and *Internet* environments allow “thick client” customers to access data with different COTS or tailored software, namely *ArcGISDesktop*, *MapObjects* or *ArcObjects* applications, allowing the combination with data derived from other different sources.

GEOGRAPHIC DATABASE

The foundation task that have been developed by IGeoE was based on the concept of an integrated and continuous GDB, not only the entire national territory, but those sets of data obtained by multilateral agreements, that could contain almost all the products from several cartographic production flows, and make them available to the general users. This system, that is currently under permanent operation, maintenance and update, constitutes an ongoing goal for the institution, and is based on an enterprise geographic database that stores several datasets existing in distinct formats and different coordinate systems, and also other features such as import, retrieve and update, creation topology and management of access controls to distinguish users with different requirements.

The key part of the system is its database (GDB). From several cartographic production flows, in vector, matrix and raster formats, at diverse scales, IGeoE has different technical specifications for each product [Martins, 2004]. For example, raster and matrix data can be seen on Table 1.

The information of the GDB is being converted (in a distinct project started in 2006 and to be concluded by 2010) from its base cartography to the UTM WGS84 system. With this conversion process, the IGeoE intends to:

- Allow for an easier and swifter use of its cartography on a scale of 1:25 000, as the coordinates in the topographic map are provided directly by the GPS receiver;
- Achieve high efficiency in printing maps and geographic documents, to cope with the urgent demands and the reduced number of editions (for instance, orthophotomaps for cooperation and peace maintenance support operations), thus providing timely and effective support to the Armed Forces Staffs,
- Comply with NATO directives and honour its Geographic Policy responsibilities;
- Provide more up-to-date and functional cartography, in accordance with internationally accepted standards.

Format / Scale / Designation	Datum/ Ellipsoid / Projection	Remarks
TIFF/1:25K/M888 (Continente)	WGS84/ WGS84/Gauss	False Origin 200K, 300K
TIFF/1:25K/M889 (R.A. dos Açores)	WGS84/ WGS84/UTM	Zone 25N/26N
TIFF/1:25K/P821 (R.A. da Madeira)	WGS84/ WGS84/UTM	Zone 28N
TIFF/1:50K/M782 (Continente)	Lisbon/ Hayford-Gauss	False Origin 200K, 300K
TIFF/1:250K/M586 (Continente)	Lisbon/ Hayford-Gauss	False Origin 200K, 300K
TIFF/1:250K/1501A (Continente)	WGS84/ WGS84/---	
TIFF/1:250K/1501G (Continente)	WGS84/ WGS84/---	
TIFF/1:250K/250k_G_Ocidental (R.A. Açores)	WGS72 /WGS72/ UTM	Zone 25N

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TIFF/1:250K/250k_G_CentralOriental (R.A. Açores)	WGS72 /WGS72/ UTM	Zone 26N
TIFF/1:250K/250k_Madeira (R.A. Madeira)	WGS72 /WGS72/ UTM	Zone 28N
TIFF/1:500 000/Carta Militar Itinerária	WGS84/ WGS84/UTM	Zone 29N
TIFF/1:5 000/Ortophotos	WGS84/WGS84/ Gauss	
TIFF/ -- / SPOT Satellite Imagery (10M)	WGS84/ WGS84/---	
GRD ¹ /	Lisbon/ Hayford-Gauss	False Origin 200K, 300K
DTED ² /--/DTED level1	WGS84/ WGS84/---	Resolution 3''
DTED/--/DTED level2	WGS84/ WGS84/---	Resolution 1''
DTED/--/DTED level2	WGS84 /WGS84/----	Resolution 1''
GeoTIFF/ /ADRG ³	WGS84/ WGS84/---	
GeoTIFF/ /CADRG ⁴	WGS84 /WGS84/----	

Table 1- Raster and matrix data from different production workflows of IGeoE.

As vector data there are also distinct formats, different coordinate systems and *data* that can be seen in Table 2.

Format / Scale / Designation	Datum/ Ellipsoid / Projection	Remarks
Administrative Boundaries	WGS84/WGS84/ /Gauss	False Origin 200K, 300K
Toponymic Report	Lisboa/ Hayford /Gauss	False Origin 200K, 300K
Administrative Boundaries Açores_Ocidental	WGS72 /WGS72/ UTM	Zone 25N
Administrative Boundaries Açor_Cent Orient	WGS72 /WGS72/ UTM	Zone 26N
Administrative Boundaries Madeira	WGS72 /WGS72/ UTM	Zone 28N
Toponymic Report Açores_Ocidental	WGS72 /WGS72/ UTM	Zone 25N
Toponymic Report Açores_Central Oriental	WGS72 /WGS72/ UTM	Zone 26N
Toponymic Report Madeira_Porto Santo	WGS72 /WGS72/ UTM	Zone 28N
1:25K/DGN ⁵	WGS84/WGS84/ Gauss	
1:50K/DGN	WGS84/WGS84/ Gauss	
1:250K/DGN	Several	
1:25K/GWS	Lisboa/ Hayford /Gauss	VMAP3 in GeoMedia
1:250K/VPF ⁶	WGS84/WGS84/-----	VMAPI
1:250K/GWS ⁷	WGS84/WGS84/UTM	Aeronautical Data
1:50k MGCP	WGS84/WGS84/-----	
DAFIF	WGS84/WGS84/-----	Aeronautical Data
GNDB	WGS84/WGS84/-----	Toponymic report

Table 2- Vector data available from different production workflows of IGeoE.

Metadata have been implemented at three main levels: 1) Theme; 2) Feature; and 3) Per each sheet of different series. Metadata was inserted according to ISO 19115 standard, having as support XML language. All “mandatory” and “mandatory under certain conditions” and some of “optional” items of the standard were considered.

INFORMATION ON THE INTERNET (IGEOE-SIG)

The IGeoE-SIG (the Geographic Information Portal of the IGeoE) is one of the components of the Army Geographic Data Infrastructure, which allows access to non-classified information.

¹ Digital terrain format

² DTED (Digital Terrain Elevation Data)

³ ADRG (ARC Digitized Raster Graphics), ARC (Equal Arc Second Raster Chart/Map)

⁴ CADRG (Compressed ARC Digitized Raster Graphics)

⁵ DGN – Design file

⁶ VPF-Vector Product Format

⁷ GWS-GeoWorkspace

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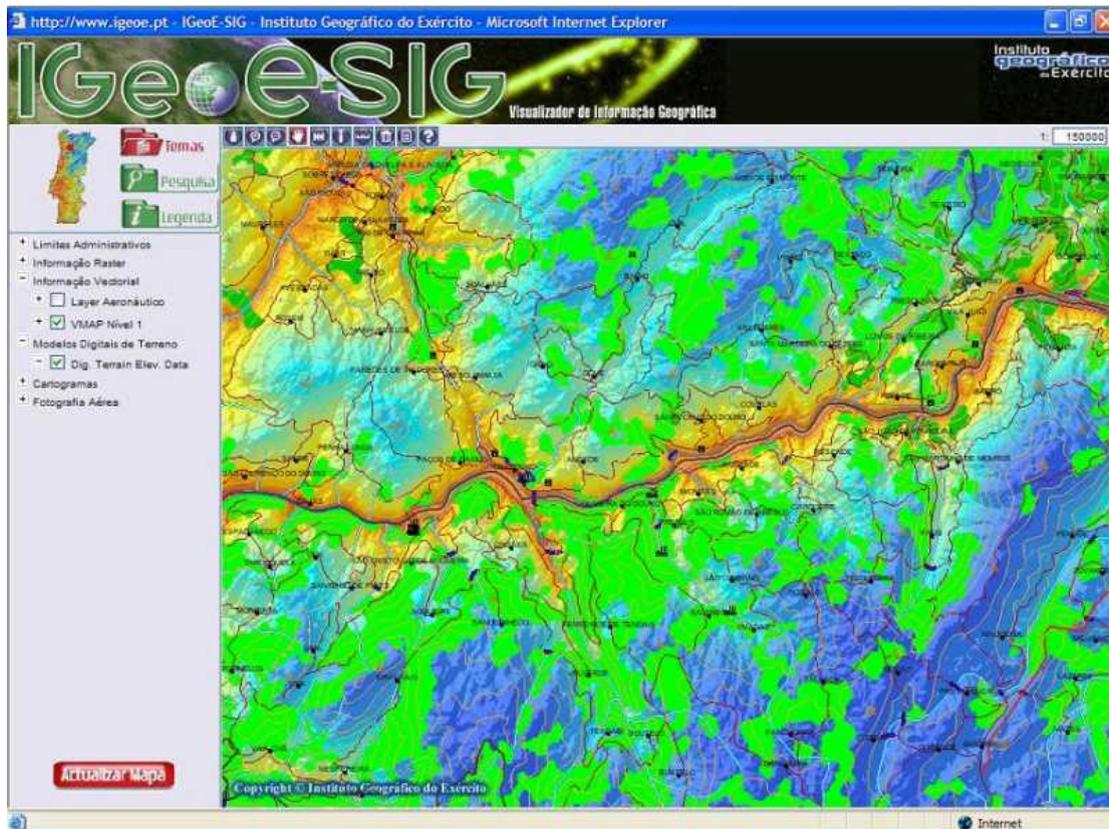


Figure 2 – The Internet component, granting added citizenship rights to the community.

This component provides the Portuguese Army and the civilian community with a continuous database covering the whole National Territory and integrating several products and data formats generated by the Institute, such as cartography (25k till 500k map series), satellite imagery, orthophotomaps and toponomy.

The technology involved is *HTML* and *VBSCRIPT* on the client side, and *ArcSDE/SQLServer* with *ArcIMS* on the server side. The minimum requirements lay on the existence of a *World Wide Web* connection and a browser.

INFORMATION ON THE INTRANET (SIG – EX)

This project aims at providing classified geospatial information via the Portuguese Army and Armed Forces Intranet in support of military operations, including the Theatres of Operations where National Forces are deployed, and areas where potential conflicts can arise.

The SIG-Ex is a geographic information portal, which includes Digital Terrain Data Levels 0, 1 e 2, Vector Smart Map Level 1 (VMAP1) and other types of data in *raster* format (CADRG, ADRG, and GeoTIFF). National Geospatial Agency (NGA) Geographic Names Database (GNDB) and Digital Flight Aeronautical Flight Information File (DAFIF) constitute also available information on this system. This information is lodged in the same database management system as the national territory data, and allows attribute and spatial search, 3D analysis, optimum path determination and other functionalities, as well as access to satellite imagery and other data available from other geospatial databases, like the Navy Environmental Database and others. The SIG-Ex will include security access that will allow data to be used, analysed, integrated and disseminated to the different military echelons, according to pre-defined privileges.

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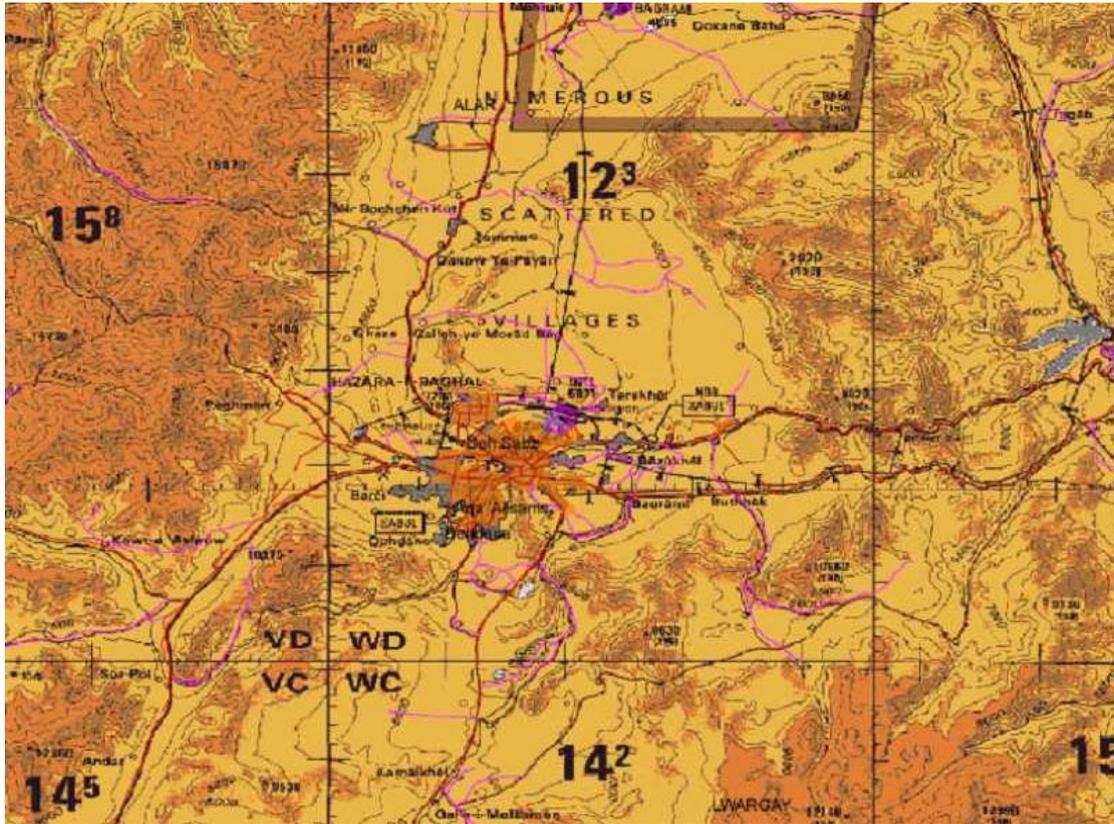


Figure 3 – The Intranet component, allowing access to classified data.

The technology used was *HTML*, *ASP.NET* and *VB.NET* on the client side, and *ArcSDE/SQLServer*, *ArcGIS Server* and *ArcObjects* on the server side. The minimum requirements lay on the existence of an *Intranet* connection, a browser and security clearance to access the different types of data.

WEB SERVICES AND DATA INTEROPERABILITY

This component of the system is in a structural phase of design and testing, and intends to implement interoperability of GDI with: 1) other civilian systems; and 2) military applications.

On the first item, the goal is to provide geospatial data to Internet civilian systems, in case the Google Earth, because is probably the most popular, with the option of data remote readout by their costumers.

Related to military applications, remote access using COTS and tailored software by “thick” clients can be done, and directly input the database data into different systems, with the possibility to combine several remote web services with their own local information (tests about data integration and services fusion are undergoing using the Navy Hydrographic Institute and IGeoE databases).

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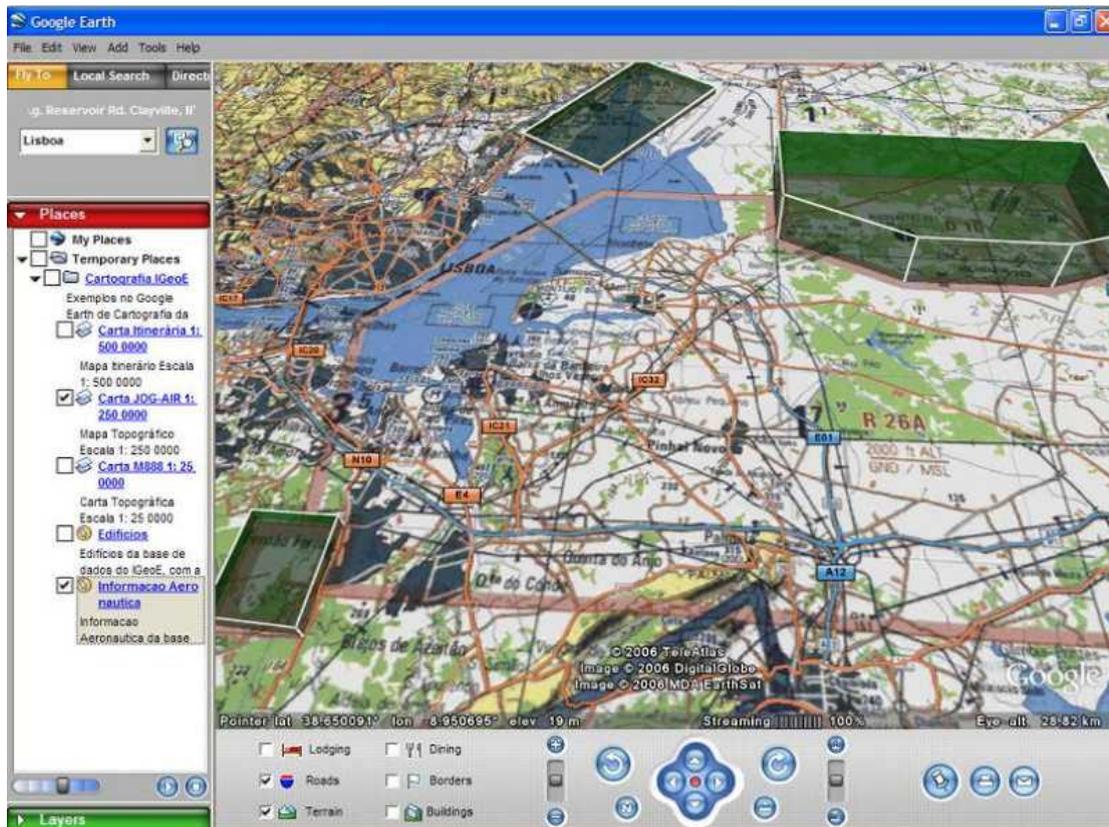


Figure 4 – Multiple Web services exploitation, using aeronautical data in vector format and Joint Operation Graphics Series in raster format.

Even though some IGeoE cartography samples are available for application on the Google Earth visualizer, further tests have to be conducted with other systems, so as allow for:

- Visualization, exploration and analysis of geospatial information on the *Internet* using 3D visualizers;
- Use of other military and civilian systems with remote data readout throughout the Internet;
- Greater interoperability between military and civilian systems using common standards like Digital Geographic Information Working Group and Open GIS Consortium;
- Real time navigation or analysis of GPS tracks, routes and points, their visualization, exploitation and insertion into the system.

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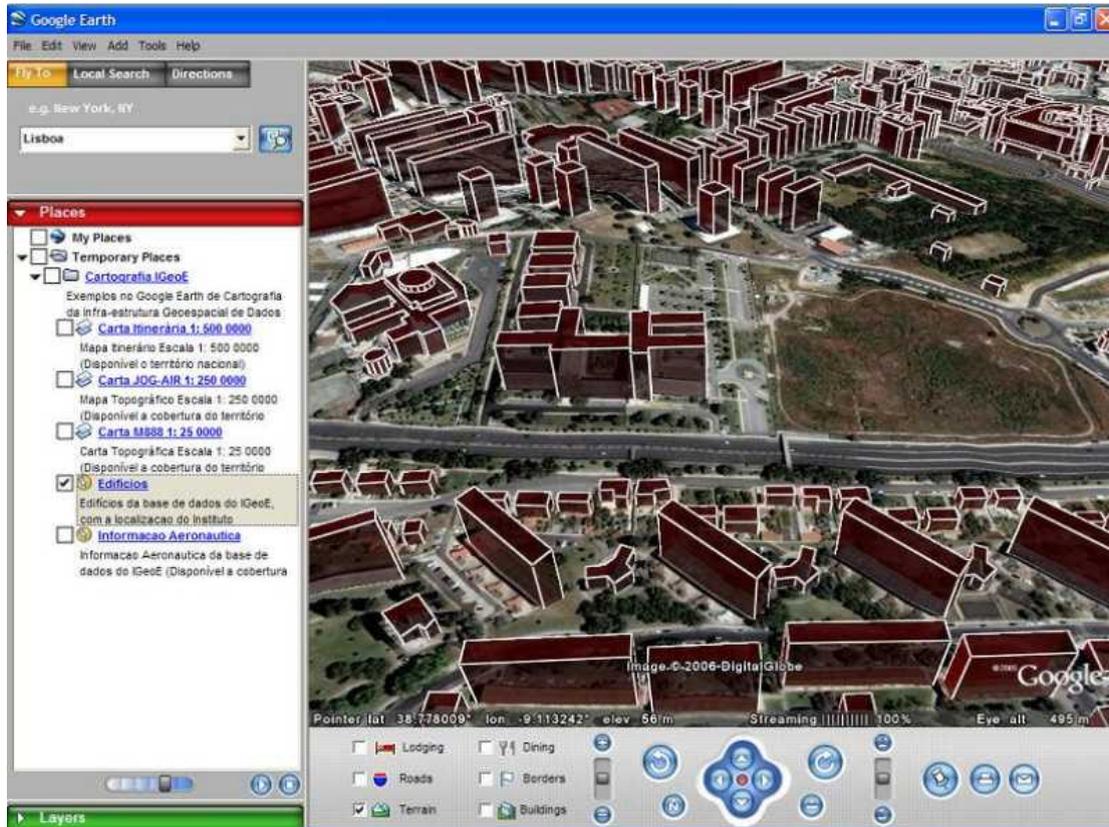


Figure 5 – Information from IGeoE GDI, being accessed by an external civil application.

STAND-ALONE APPLICATION

The need for an application (IGeoE-MAP) to use in Pen-Top and PDA hardware spread throughout the Portuguese Army and Armed Forces on the operation theatres that could guarantee portability by human, vehicle and airships generated another requirement for a GDI component.

IGeoE-MAP reads and displays normalized digital cartography formats produced by NATO, DGIWG, NGA and other official entities, in different projections systems and data throughout the World.

The functionalities and capabilities implemented can be divided in several tools:

- 1) Vector & Raster Visualization;
- 2) Attribute & Spatial Analysis;
- 3) Distances & Areas Measuring;
- 4) Georeferencing;
- 5) Remote Access to GDB in pervasive and ubiquitous environment;
- 6) Printing;
- 7) Network Analysis (Routing);
- 8) Real Time GPS Connection with Radio Transmission capability;
- 9) 3D Visualization and Analysis.

To achieve all the requisites, it was decided to implement IGeoE-MAP in MapObjects 2.2, using Visual Basic 6 in a modular environment. The main reasons were that it was simple to develop, adapt, change and tailor according to different users requisites, and also because it had the capability to integrate the main raster and vector formats, required and produced by several equipments and countries, in multinational and coalition operations.

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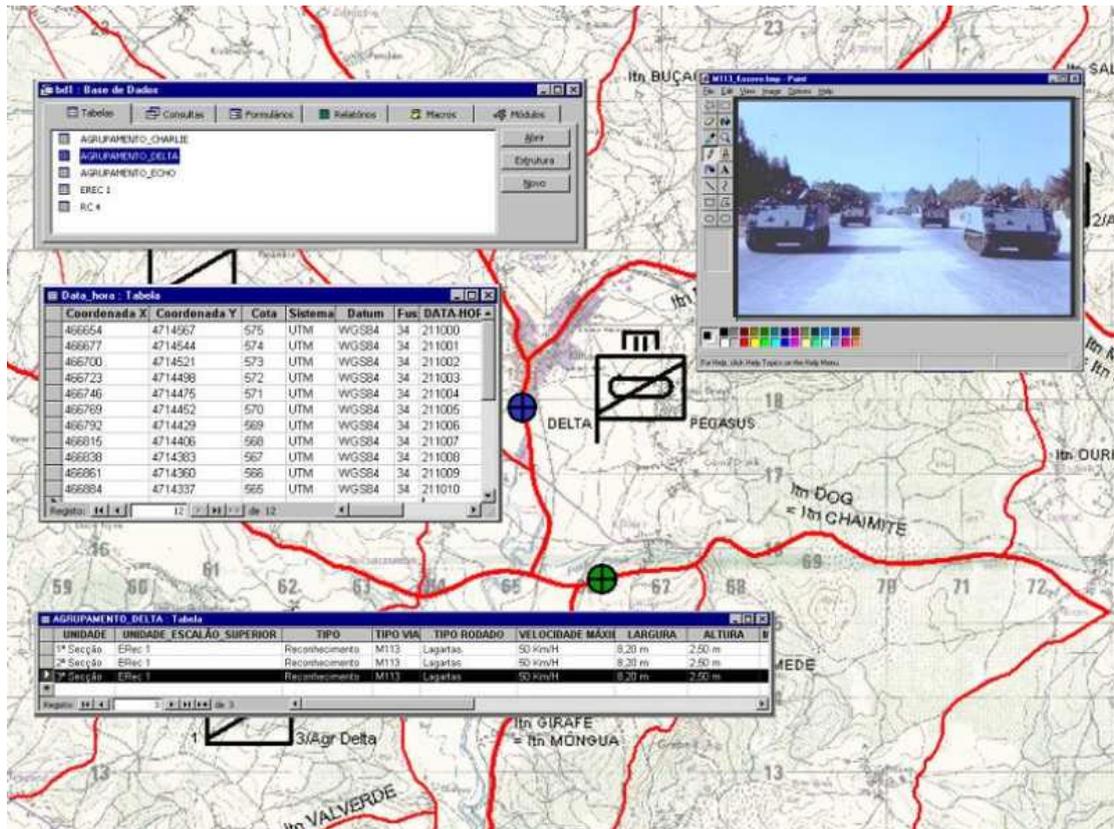


Figure 6 – IGeoE-MAP in pervasive and ubiquitous environment. The example is a real time navigation with GPS equipment.

CONCLUSIONS

This paper presents the context, goals and technical decisions and issues of the on-going system promoted by IGeoE, the Army Geographic Institute, in Portugal, responsible for the production and maintenance of cartography at the 1:25.000 scale. This system, called GDI, Geospatial Data Infrastructure, was developed, tested and implemented in a modular basis, an integrated and robust system based on an enterprise solution with COTS software and a common Geographic Database (that can store almost all the data produced by the institute and received under international agreements) and application interfaces for *Internet*, *Intranet*, stand-alone environments. Still, the GDI system provides a set of *Web* services attending the requirements of specific users in diverse operational activities.

Based upon this structure, the distribution of geoinformation to the Armed Forces, particularly the Army throughout *Intranet* is a reality. However, there is still a lot of work ahead, due to the fact that a lot of functionalities required by the military are not yet developed. Full integration of IPB and Military Decision Process derived from internal information of the system is only at the first beginning.

Also the civilian community is benefiting from such a structure, cause it allows also to visualize, analyse and explore data in an open *Internet* access, grating additional citizenship rights to the normal user.

Utilization of up-to-date technologies, according to differentiated user requirements, allows information accessibility using a simple browser based on *ArcIMS* for thin clients, *ArcGIS Desktop* connections to *Web* services for “thick” clients, a browser in an *ArcGIS Server* environment for common clients, and a stand-alone application developed in *MapObjects* for disconnected users.

The Geospatial Data Infrastructure has been tested for example in the contexts of new armoured vehicles acquisition to the Portuguese Army and Marines, the Health Department, aerial accidents prevention and monitoring, fleet management,

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and more recently in NATO LIVEX06 Steadfast Jaguar exercise integrating MGCP data from Cape Verde in support of national troops involved.

Tools available generally allow visualization, attribute and spatial querying, coordinate transformation, network analysis and real time GPS navigation with digital radio transmission, among others. Terrain exploitation and 3D analysis is currently under development and improvement, to integrate functionalities like fly-throw, automatic discovery of mobile corridors, helicopter land sites and others.

The experience obtained from the conception and development of this Multirole Geospatial Data Infrastructure allows a bright vision to the future. Ultimate goal is a massive access and availability to the general public, military, universities and schools, allowing a higher knowledge, deeper education and improved exploitation of Digital Geographic Information.

REFERENCES

1. **MARTINS, P. 2004.** *A Informação Geográfica do Instituto Geográfico do Exército na Web*. ESIG 2004, Lisboa, Portugal.
2. **NUNES, L. 2004.** *GeoExército: Concepção do Sistema Tático-Estratégico do Exército Português*. Master of Science Thesis, IST, Lisboa, Portugal.
3. **ESPINOZA, F. 2002.** *Individual Service Provisioning*. Akademityck AB, Doctoral Thesis, Stockholm University. PhD Dissertation. Dept. of Computer and Systems Sciences. Suécia.
4. **MARINE CORPS. 1998.** *Marine Corps Doctrinal Publication*. On-line publication of the Marine Corps Doctrine Division. US. URL: <https://www.doctrine.usmc.mil/pcn.htm>

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