EXPLOITATION, ANALYSIS, AND NAVIGATION FOR MILITARY, EDUCATIONAL, AND RECREATIVE PURPOSES

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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.

One of the main projects have consisted in the development of a support appealing tool using VB6 and MapObjects 2.2, integrating the products originated from the production flow in vector, matrical and raster format, at diverse scales of the Portuguese territory, like orthophotos (1:10k), cartography (1:50k, 250k, 500k), satellite imagery, Military Cadastre database and standard military products like VMap1 and 3 (Vector Smart Map level 1 and 3), DTED1 and 2 (Digital Terrain Elevation Date level 1 and 2), CADRG (Compressed Arc Digitized Raster Graphics) and GeoTIFF. The ultimate goal is availability to the general public, military, sportsmen, military academies, university and schools, trying to approach them to a higher knowledge, deeper education and exploitation of Digital Geographic Information.

The developed tools allow the visualization, attributes and spatial search, coordinate transformation, image georeferencing, network analysis and real time navigation with digital radio transmission, among others in a pervasive and ubiquous environment.

INTRODUCTION

The Geographic Institute of the Army (IGeoE) is the cartographic institution responsible for the Portuguese base map, which is the most used information in GIS for civilian and military purposes in Portugal. Now positioned within the Logistics Command of the Army, IGeoE routinely produces several cartographic products in a variety of analogue and digital formats:

- Topographic Maps at 1:10K, 1:25K, 1:50K and 1:250K scales;
- NATO Maps at 1:50K and 1:250K scales;
- Orthophotomaps at 1:5K and 1:10K scales;
- Satellite Imagery at 1:50K scale;
- Itinerary Maps (Civilian) at 1:250K and 1:500K scales;
- Digital Terrain Models (8 meters grid resolution, DTED1 and DTED2);

IGeoE is certified by ISO 9001 and ISO 14001 standards and although the quality, precision, availability and normalization of their Digital Geographic Information, which are major aspects that characterize it, their use by the normal citizen and the military community in general, is still one gap to be transposed.

The request for an application that could read and combine digital products from IGeoE, arises from the fact that most of the users doesn't have the knowledge and training to take advantage of digital data. Usually, their concerns lay on the great number and complexity of functions available in commercial software, compatibility of the data with other systems, lack in exploitation of their potentialities, and the use of it with Global Positioning Systems (GPS) equipments. In resume, users would like to

have at disposal an application produced or certified by the body that also produces the cartographic data, so that in case of doubt, have someone to dialog with.

As producer of Digital Geographic Information (DGI), one of the endeavours of IGeoE stands now for making available to the general public and the military community a tool, that allows the visualization and exploitation of data produced, to publicity it and increase their use to the maximum extent. To accomplish this, one of the ways stands as a form of a stand-alone application with the capability to remotely access the Geographic Database (GDB) of IGeoE, throw *Intranet*, *Internet,* or digital radio transmission, in a pervasive, ubiquous, distributed and centric services environment. The development of such an application is being made by the newly created Center for Development and Managing of GeoInformation.

In an increasingly demanding world, where the use of DGI is almost unavoidable and is present in our daily lives, the knowledge derived from this kind of project serves also to produce tailored products to more sophisticated customers and purposes. Examples of these, are the use by Portuguese armed forces in multinational coalition forces environment, like in Afghanistan, Iraq and East Timor, and the use by National Guard, Civil Protection and Health Departments in support of the European Soccer Championship, or in daily routine. The employment in major staffs, military academies and even the other branches of the armed forces, are also other aims of this project, to improve decision support and situation awareness in the military decision process, providing a common picture of the battlefield.

IGEOE GEOPRODUCTION CONCEPT

Another important task that have been developed by IGeoE is based on the concept of an integrated and continuous Geographic Database (GDB) of the entire territory, that could contain almost all the products from the several production flows, as the ones mentioned in Section 1, and make them available to the general users. This project that is currently under development and constitutes an ongoing goal for the institution, has the foundations on an enterprise geographic database solution, that can store several datasets existing in several formats and different coordinate systems, import, retrieve and actualise them, create topology and permit controlled access to differentiated users on several distinct ways.

To achieve the implementation of such a system, it was decided to use *Commercial Off-the Shelf* (COTS) applications. Specifically, *ArcSDE* software with *SQLServer* database environment, was the path followed. The publication of data throughout the *Internet*, military private *Intranet*, operational and administrative units, or even the normal citizen, is being granted by the use of *ArcIMS*.

Along with obvious advantages for the civilian community, the support of the Military Decision Process (MDP) is also an ongoing goal, trying to include all levels of military hierarchy though in peace keeping, coalition or civilian community support operations. A closer look to the system can be taken at Figure 1., where we can see the users involved and the different ways to access the system [Nunes, 2004]:

1) The departments of photogrammetry, remote sensing and topography (PHOTOD, RSD, TOPOGD) guarantee the acquisition of data to the geographic database;
2) The commercialisation department (CD) is responsible for direct relation with the customers, the transactions and copyright details. They can access the GDB directly, to allow direct export from DGI products to satisfy clients needs;
3) DGI can be supplied and received by Intranet, to provide support for the major staff of the army (EME), operational brigades (BAI), operational command of ground troops (COFT), the infra-structures agency of the minister of defence (DGIED) and others;

4) Another user is the normal citizen that can consult, query and visualize data throw a normal Internet connection improving their citizenship rights;

5) The National Overseas Forces (NOF) utilize normally stand-alone applications, due to the fact that they are separated from the mainland and direct access can not be done throw a robust network. They also need to communicate and visualize their position in a local digital radio network. Special Forces (SOGAs, COE, GALE) need only stand-alone application so they can't be detected.
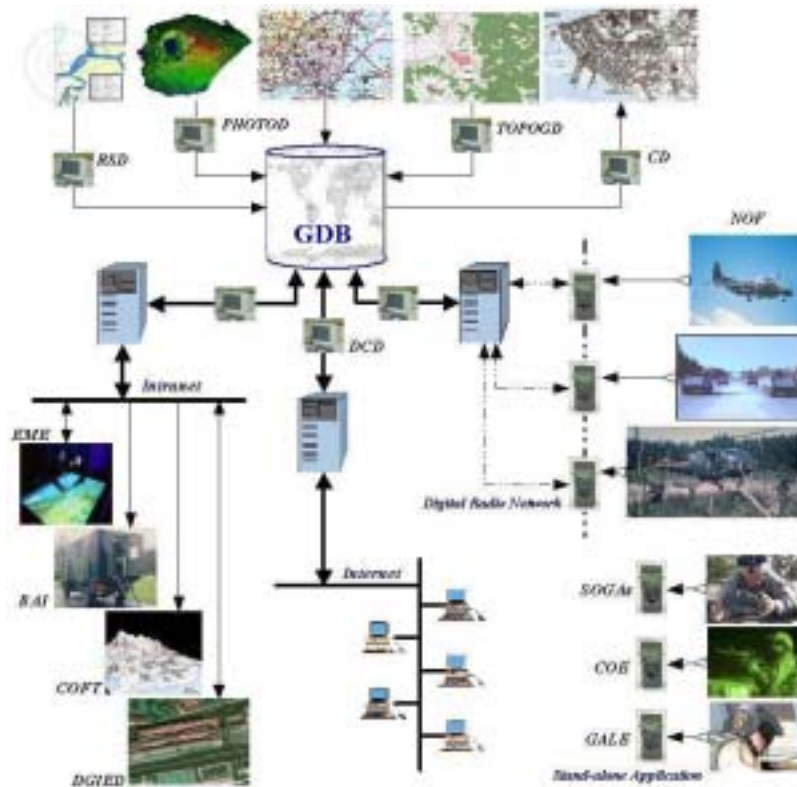

Figure 1 – IGeoE geoproduction conception.

In resume, we could say that from the general systems can be identified different needs from the users, several ways to access DGI and deliver it, though leading to distinct sub-systems. Internet, Intranet, Digital Radio Network and Stand-alone are the applications that have being implemented and developed.

VISUALMAP SUB-SYSTEM

As orientation parameters for a stand-alone application, the sub-system (called VISUALMAP) requisites that had been considered for this kind of project were that it would be able to run in Windows 2000 and XP platform, and the space occupied by the application should not exceed the 15 MB. This is mainly justified by the Pen-Top and PDA hardware used throughout the Portuguese Army and Armed Forces on the field, and to guarantee the portability by human, vehicle and airships.

VISUALMAP should also be able to read and display normalized digital cartography formats produced by NATO, DGIWG, NIMA and other official entities, in different projections systems and *data* throughout the World.

The functionalities and capabilities considered to implement can be divided in several tools (see Figures 2. and 3.):

1) Vector & Raster Visualization;
2) Attribute & Spatial Analysis;
3) Distances & Areas Measuring;
4) Georeferencing;
5) Remote Access to GDB in pervasive and ubiquous 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 VISUALMAP 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.
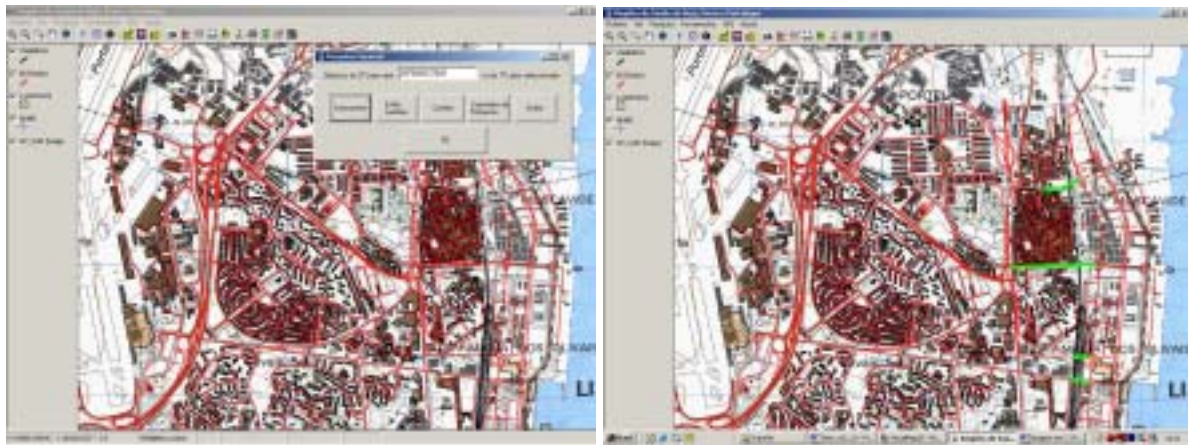

Figure 2 – VISUALMAP interface. Visualization of road and railroad networks, urban area (all in shapefile), and image at 25k scale (TIFF format). In this case, a spatial query, to find potential danger roads that cross the railway.
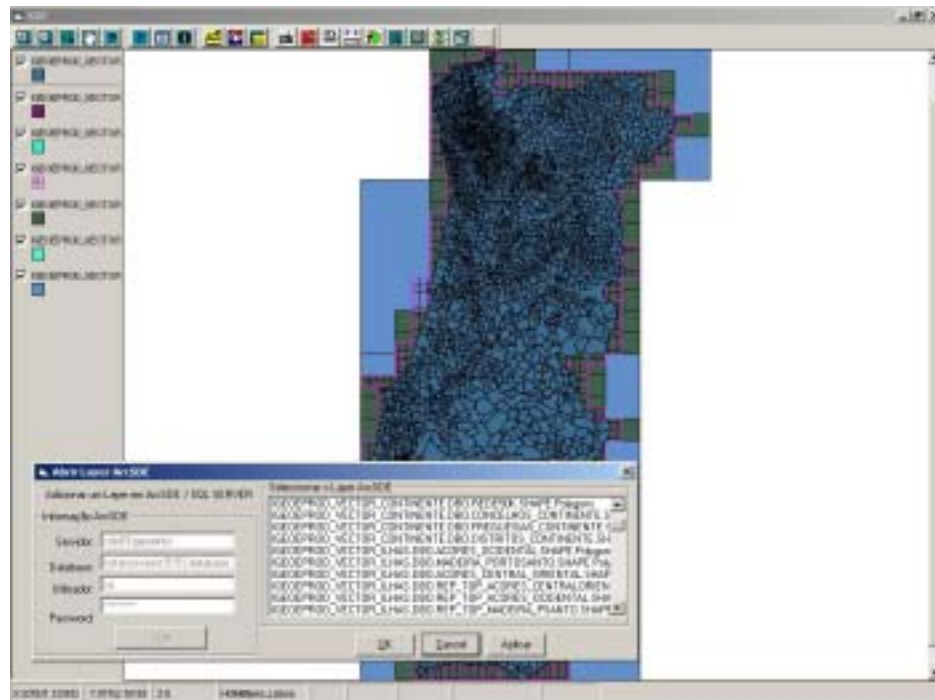
Figure 3 – VISUALMAP in pervasive and ubiquous environment. The example is a direct connection to the GDB in SQL Server, throw Army private intranet.

THE DATA

This project consists in development of an appealing tool using MapObjects 2.2, but without data integration there is no system at all. From the 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.

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
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''

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[1] Digital terrain format
2 DTED (Digital Terrain Elevation Data)

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
Toponimic Report	Lisboa／ Hayford ／Gauss	False Origin 200K, 300K
Administrative Boundaries Açores_Ocidental	WGS72 ／WGS72／ UTM	Zone 25N
Administrative Boundaries Açores_Central Oriental	WGS72 ／WGS72／ UTM	Zone 26N
Administrative Boundaries Madeira	WGS72 ／WGS72／ UTM	Zone 28N
Toponimic Report Açores_Ocidental	WGS72 ／WGS72／ UTM	Zone 25N
Toponimic Report Açores_Central Oriental	WGS72 ／WGS72／ UTM	Zone 26N
Toponimic 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／-----	VMAP1
1:250K／GWS[7]	WGS84／WGS84／UTM	Aeronautical Data

Table 2- Raster and matrix data from different production workflows of IGeoE.

All this data had to be converted to match the proper formats read by MapObjects 2.2 (MO2.2). Direct connect can be done with the vector data existing in the GDB, because the format of the geoinformation resulting from the use of ArcSDE is blobs. However, raster data can't be accessed directly in the GDB due to the fact that there is a limitation in MO2.2. To solve this problem, raster data has to be accessed in its native format or converted to a legible one.

The problem with the terrain model for 3D visualization and analysis is a little bit complex. MO2.2 don't allow the visualization and exploitation of DTED, which is one of the most used formats by military forces. To achieve the 3D capabilities there was the need to implement a functionality that could read the elevation data of that product, and also the capability to export user works and analysis in a proper format read by MO2.2.

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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

As a synthesis, we can see in Table 3. the formats read directly by VISUALMAP.

Format	Extension
Shapefile	shp
VPF	dht
CAD	dgn,dxf,dwg
Imagery	bmp,jpg,jpeg,tif,tff,tiff,gis,lan,bil,bip,bsq, sid,sun,rs,ras,rlc
Elevation Data	dt1, dt2, bmp, bsq

Table 3- Different data formats available in VISUALMAP.

CONCLUSIVE SYNTHESIS

IGeoE is developing, testing and implementing in a modular basis, an integrated, continuous and robust system, based on an enterprise solution with software *Commercial Off-the Shelf* (COTS) and comprised of a Geographic Database that can store almost all of the data produced by the institute.

Based upon this structure, the distribution of geoinformation to the Armed Forces, particularly to the Army throw *Internet* and private *Intranet* is a reality. Also the civilian community can benefit from such a structure, cause it allows also to analyze and visualize data in an open *Internet* access.

To fulfil the needs from the users, however, there is a great demand for tailored applications, to be used by National Overseas Forces, specific territorial forces and Special Operations units in support to the Military Decision Process. To satisfy not only these users but also the normal citizen, a sub-system has being developed with some interesting results. VISUALMAP has been tested for example in the contest for acquisition of new armoured vehicles for the Portuguese Army and the Marines, the Health Department in support of the European Soccer Championship, and fleet management.

Tools allow visualization, attribute and spatial querying, coordinate transformation, image georeferencing, network analysis and real time GPS navigation with digital radio transmission, among others. The terrain visualization and analysis is currently under development and improvement, to integrate functionalities like fly-by, automatic discovery of mobile corridors, helicopter land sites and others.

The experience obtained from the conception and development of this sub-system allows a bright vision to the future. Ultimate goal is also a massive distribution and availability to the general public, military academies, universities and schools, allowing a higher knowledge, deeper education and improved exploitation of Digital Geographic Information.

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