GIS (GEOGRAPHIC INFORMATION SYSTEMS) IN CCIS (COMMAND & CONTROL SYSTEMS)

L. Ucuzal [a] , A.Kopar [b]

[a] BİLGİ Geographic Information, Conversion and Management Systems, 30. Cadde 26/30 06530 KaraKusunlar/ANKARA- leventu@bilgigis.com,
[b] 3 ncu Kolordu K.Ligi Is. S. 34398 Ayazağa Istanbul, Turkey – akopar@yahoo.com

Key Words; ATCCIS (Army Tactical Command and Control Information System), GIS (Geographic Information System), COP (Common Operational Picture), CCIS (Command & Control Information Systems), LRP (Land Recognized Picture), MRP (Maritime Recognized Picture), ARP (Air Recognized Picture), MIP (Multilateral Interoperability Program), NATO ACE ACCIS (NATO Allied Command Europe Automated Command, Control and Information System), NC3A (NATO Consulting, Command and Control Agency), NIMA (National Imagery and Mapping Agency).

ABSTRACT

Since the beginning of the mankind, the military forces have played an important role in the society. The most important change from the historical time until today has been the revolution of technology, which brings the use of high technologies in battlefield management.
Today, in defence bodies there are various Command & Control Information Systems (CCIS); Common Operational Systems, Naval, Land and Air Operations, Intelligence, Security, Logistics Systems, National Security, Position and Location Tracking Systems, Military Estate Information Systems, Meteorology Information Systems, position based Missile and Weapon Guidance Systems and etc. Almost in all of those projects, there is a strong need for Military GIS (Geographic Information Systems) with specific functionalities at theatre.
This article will discuss the position and importance of GIS in CCIS and similar systems and evaluate the situation of GIS in CCIS today.
The discussion will further be extended with the experience that is gained about the existing situation of the available map data, how the map data can be used in an effective level in such systems, what are the problems, how they will be served on a LAN, WAN and WEB based networks with a very high performance. The trends today will be discussed for those issues.
On the other hand, we will be considering the basic concept of a "light weight " WEB based functional application of Common Operational Picture – COP as an example of use of high performance GIS on WEB based CCIS applications.

KURZFASSUNG

Seit jeher hat in der Menschheitsgeschichte das Verlangen nach militärischer Überlegenheit auch die technologische Weiterentwicklung vorangetrieben. Dazu gehört heute auch die Nutzung neuer Technologien für das Management des Gefechtsfeldes. In Streitkräften finden die verschiedensten Command und Control Informations Systeme (C2IS) Anwendung, wie zum Beispiel Systeme zur Führungsunterstützung von Land-, Luft- und Seeoperationen, Systeme zur Nachrichtengewinnung und Aufklärung, Logistiksysteme, Systeme für nationale Sicherheit, Positions- und Überwachungssysteme, Systeme für die Verwaltung militärischer Einrichtungen, Wetterinformationssysteme, Feuerleitsysteme und etliche andere mehr.
Nahezu in all diesen Systemen sind Daten/Datenverarbeitung durch ein militärisches geographisches Informationssystem (GIS) mit speziellen Funktionen notwendig.
In diesem Artikel soll die Bedeutung von GIS in C2I-Systemen dargestellt und diskutiert werden.
Die Diskussion soll weiterhin um die Punkte erweitert werden, inwieweit geographische Daten und Karten verfügbar sind und wie diese Daten effektiv genutzt werden können. Es soll dargestellt werden, worin Probleme liegen, z.B. bei der Datenübertragung via LAN, WAN und WEB basierender Netzwerken mit hoher Übertragungsrate. Weiterhin soll ein Ausblick auf zukünftige Trends gegeben werden.
Zudem soll das Konzept einer 'light' WEB basierenden Anwendung eines 'Common Operational Picture (COP)' als ein Beispiel der Nutzung von leistungsstarken GIS bei C2I-Systemen vorgestellt werden.

1. INTRODUCTION

Today the most important weapon of the developed countries has been the technology and the use of information technologies in the field. Since the beginning of the mankind, the intelligence about the enemy forces has played a critical role for the success against the enemy. But, the acquisition of the information, interpretation and transmission to the decision makers are also important parts of the decision making systems. The concepts come out with the transformation of the information pushes the value of the having the technology as a critical constraint. And this also shows the hardness of the production of the technology on the arena. For that reason it has been very important to produce the technology today [1].

As it is in the Gulf war, the technologies are fighting with each other. Sometimes with the technology the expectations are forced to the opposite without any war. And sometimes the war ends in a very short time due to the technology.

One of the most important part of the all types of battlefield, the intelligence and operations information of the enemy and own units as updated, fast, accurate and interpretation of those, and the action plays very critical role for the success.

This issue has been proved at the war of Iraq for the coalition forces. In an article, "Electronic Today of November 1996", Major General Gurbaksh Singh VSM, says that; "The lessons learned from the military history shows that without caring the size of the enemy forces, the key to win the war is to be one step further then the enemy in terms of time and accuracy for the command, control, communication, electronics and information systems.

If the defense and the weapon system can warn the attack's time, and position with high accuracy and enough information then it is easier to get the required position before the enemy and destroy it"[1].

This approach shows the importance of the spatial information and its accuracy and timing in the command center for the commander/decision maker.

2. DEFINING GIS IN MILITARY

The rapidly developing technology and changing needs and increase of the population have forced importance of information.

The effect of technological developments to human life can not be ignored. For the positive effect of those technologies to the public life, there is a huge need for all types of information. The acquisition of those information, storage of them, analyzing and make them ready for the use of people becomes very important for the advantages that is expected to provide.

Together with obtaining the information it is also critical to present that information to the right place, at right time as accurate and updated.

One of the technologies that are used to manage the information is Geographic Information Systems (GIS). This technology, via the link the various types of the information in a computing environment provide analyzing tools for decision makers and save their time[1].

When we link the very complex spatial information with nonspatial information with a geographic model it becomes easier to make the analysis with and use it.

At the spatial information systems, it becomes important to setup up and use a relational database with spatial and nonspatial information. For that reason, the collection, storage, processing and presentation for the usage of the spatial information is only possible with a good design of the system and with the tools that can do this. For those purposes there has been some special systems developed. Those are generally called GIS. According to Burrough (1986, p.6); 'GIS, is the whole set of tools for collecting, storing, querying, transferring and displaying of all data on the earth surface for a specific goal." According to that there are 2 concepts that affect the definition;

One is the different disciplines that uses may define GIS according to their scope. The second one is the experts at those disciplines use the GIS for their specific needs to be done. GIS, like any new technology that comes out, provides many tools to make the experts' studies more valuable and productive.

2.1 The Basic Components and Objectives of GIS;

GIS, with a basic understanding, covers 4 components;

a) Geographic data,
b) Hardware and software,
c) Experienced people,
d) An objective for a specific problem.

All those components above have equal importance for the success of GIS.

Together with that, there are 3 basic objectives of GIS;

1. The storage, management and integration of huge data. That spatial and nonspatial information are related to each other and analyzed. Spatial data are point, line and area, and nonspatial data are descriptive information about those geographic features. At the end we do have two main different type of data that are managed in GIS;
   a) Cartographic data (point, line, area and grid).
   b) Attribute data (descriptive tables).
2. To analyze the geographic data such as where are the areas that are under the coverage of enemy's weapons? Modeling of logistic routes for the battlefield, and etc.
3. To manage all those types of data with the ease of use for the users.

2.2 The Map Data in Military [2];

2.2.1 The Maps & Charts; For the use of GIS in CCIS we need the maps to be prepared and stored in databases for uses. There are different maps that can be used in CCIS systems fore various purposes;

2.2.2 Large Scale High Resolution Imagery; The high accurate imagery from aerial and/or satellite imagery are used for various intelligence purposes mainly for Land and Air operations including target positioning and fire coordination.

Figure 1. High resolution images

2.2.3 1/25 000 & 50 000 Maps and Charts; The large scale 1/25 000 & 50 000 Topographic maps and Special Naval charts (Level 2 Digital Data) are used for land, air and amphibious operations in defense and offence. They are also used in small quantities for operational planning and detailed intelligence work. In many cases, topographic series also meets this military requirement.

2.2.4 1/250 000 Maps and Charts (Level 1 Digital Data). The 1/250 000 Maps and Charts (Level 1 Digital Data) are used in large quantities for land and air movements (including low level transit flying), together with logistic operations. Again, small quantities are used for general planning and intelligence work. The standard military series, Joint Operations Graphic, is frequently supplemented by national road maps and special helicopter charts.

Figure 2. Level 1 Digital Data

2.2.5 1/500 000 Maps and Charts The 1/500 000 Maps and Charts are used in large quantities for land and air movements, including medium level flying operation, together with small quantities for general planning and orientation.

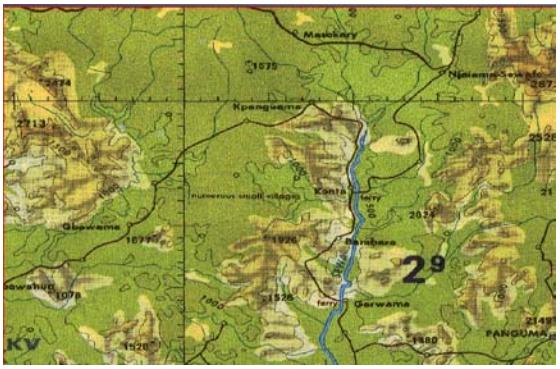

Figure 3. 1/500 000 scale Raster Scanned Image

2.2.6 Small Scales (1/1M and smaller) (Level 0 Digital Data). At Scales of 1/1M and smaller, (Level 0 Digital Data), the international military air chart Operational Navigation Chart or Series ONC are used in large quantities for flying operations, although the scale is also used in small quantities for orientation and outline planning. The Digital Chart of the World (DCW), derived from the ONC, is the standard Level 0 digital product.

Figure 4. Level 0 Digital Data

2.2.7 Nautical Charts. Nautical charts differ from land maps (and military air charts) in that they are provided at a scale and content that suits the area depicted and are generally common to both civil and military uses, through the co-ordination of the International Hydrographic Organization (IHO). However, there is a requirement to combine the nautical chart information with the topographic map information in the Special Naval Charts, such as the Combat Chart covering the shallow water, over the beach to the land, to support amphibious operations.

2.2.8 Military Geographic Information & Documentation (MGID). When MGID is provided as a map overprint, such as a Training Area or Roads & Bridges (R&B) map, then the product concerned is normally designated in the same manner as the base map. Other MGID, such as the toponymic information in a Gazetteer, is only available in book form. However, some critical MGID, such Digital Terrain Elevation Data (DTED), has no "hard copy" equivalent and, although standardized in format, currently remain non-designated.

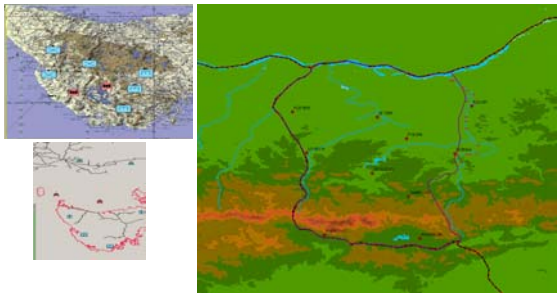

Figure 5. Map overprints (Roads & boundaries)

2.3 The Uses of GIS in Military;

There are many different uses of GIS in military. Some of them are;

2.3.1 Command, Control, Communication, Information Operations and Intelligence Systems; the entire map data mentioned above are used for various purposes and functional applications subsystems at military CCIS systems. All of those systems somehow depend on the positioning and so map background with analysis tools that is GIS.

2.3.2 Unit/Troop Tracking Systems (GPS); The units, organizations and even troops are tracked via GPS embedded equipment on the different levels of maps.

2.3.3 Intelligence and Operations systems; Small quantities of maps and charts are required to support the collection of military intelligence. The primary requirement, for collation of such military information, is that the maps be current, with detailed toponymic and cultural information. Although position information is required, if this can be provided from other sources, then it is not essential on the intelligence map or chart itself. Currency of information is of prime importance, together with the ability to associate the information within an appropriate position referencing system. Where possible, maps are supported by photographic or other imagery. In other words, the most up-to-date geographic information is essential, together with the ability to relate it back to the standard products used by the operators.
The requirement for military operations is that detailed map and chart information be available, in sufficient quantities, for all forces concerned. These maps and charts must be current, contain standard navigation and position information (in the form of a grid or graticule) plus detailed topographic and hydro graphic information. Interoperability and standardization of information is of prime importance[3].

2.3.4 Logistic Information Systems; Planning for logistics with detailed route definitions, distribution models, shortest path analysis, query and display of the facilities and logistic infrastructure and other related issues are fundamentals of GIS Logistic Information Systems.

2.3.5 Electronic Warfare Systems; All electronic warfare systems require terrain data either for analysis or for display.

2.3.6 Radar Coverage and Frequency Analyses Systems; For the site selection of the radars and radio antennas, coverage area analysis, propagation analysis, weapon and or missile corridors, flight corridors and etc. are analyzed and displayed via GIS tools.

2.3.7 Common Operational Picture (COP), Land/Maritime/Air Recognized Picture; This is totally a new concept in GIS. The details are discussed below about that concept.

2.3.8 3D Terrain Modeling, Drape and Fly Through Systems; It is important to model the terrain and evaluate it before the operation. Draping of various accuracy maps and imagery on the terrain also is very helpful for intelligence. This technology is also used for flight simulation.

2.3.9 Military map browsing Systems; Together with the central use of GIS data, increase in the performance of GIS data usage with multi-user environment, it has been very popular to browse the maps on the web. As mentioned above the maps are very intensively used for various purposes and the high performance access to the maps is very important now with easy to use browsing capabilities.

2.3.10 And others, including other geographic analysis such as profile analysis, distance measurement, angle measurement, night visibility analysis, military overlay preparation tools, scaled and oriented value added map re-production, fire coordination systems, deployment and transportation planning-monitoring systems etc.

3. THE TRENDS & SAMPLE CASE; COP (COMMON OPERATIONAL PICTURE) CONCEPT;

3.1 Tests to Evaluate the Trends

The character of Geographic Information Systems (GIS) in Command and Control Systems has been changing in last years. Instead of being a supportive but largely independent service to the operations, they've become fully integrated at nearly all level of C2 systems.
At this section of the paper we will discuss about the new technologies and their roles in Command and Control

systems based on some tests and trials that have been done in various military bodies. For the technological evaluations of GIS in CCIS systems, there have been many tests. The tests that have been done around in various military bodies concentrated on mainly;

a) Comparison of WEB and Client/Server architectures,

b) Comparison of RDBMS and file system storage of spatial data.

Under those basic circumstances the tests are based on the criteria such as data access, query, display, symbolization, zoom in/out, panning and etc. On those tests, the type of the data used is 2D/3D Raster and Vector data, satellite imagery and gazetteer data.

The results of those tests can be summarized as;

In terms of comparison of RDBMS and file system storage of spatial data:

- In the database storage; security, update and raster data access are `Easy` but in the file system, they are `Hard`.
- Open format standard is available for database storage but not for the file system.
- Response speed is `fast` for database storage but `slow` for the file system.
- Indexing is available for database storage but `limited` for the file system.

In terms of comparison of WEB and Client/Server architectures:

- There is no need for; high capacity RDBMS server, high capacity WEB GIS server, high capacity network b/w client and server, high capacity network b/w RDBMS server and Web server for the WEB Architecture, but all those are necessary for Client/Server architecture.
- Technological future expectations are exist for WEB Architecture, but not for the Client/Server architecture.
- Response speed is `Fast` in WEB Architecture but `Slow` in the Client/Server architecture.
- Network load is `Low` in WEB Architecture but `High` in the Client/Server architecture.
- Management and SW upgrade is `Easy` in WEB Architecture but `Hard in the Client/Server architecture.
- Cost of the WEB Architecture is ` Low after 50 users` but `High` in the Client/Server architecture.
- Unnecessary Functions are `Limited` in WEB Architecture but `Many` in the Client/Server architecture.

In line with the assessments above; the most effective architecture is **"WEB based GIS architecture with RDBMS based spatial data storage"**

3.2 The Implementation of the Test Results at the COP (Common Operational Picture) Concept

The COP was designed for two purposes. One of them is to be a situational awareness tool for the majority of the users for assigned Areas of Responsibility (AOR) and Areas of Interest (AOI). Especially for the decision mechanism, functional enhancements such as logistics, intelligence etc. provides multi dimensional view of the theatre. Second purpose is, to be a decision support utility via monitoring, recognized Maritime, Air and Ground pictures on a single screen. Thus, COP provides basically data sharing and co-operative working opportunity in other words information flow among various information systems and user groups via network. Interoperability is secured by common GIS environment and integral Functional Information such as operation, intelligence, logistics etc.

COP has the ability to show the;

- Maritime Recognised Picture
- Ground Recognised Picture
- Air Recognised Picture
- Intel Recognised Picture
- Logistic Recognised Picture
- Meteorological Picture

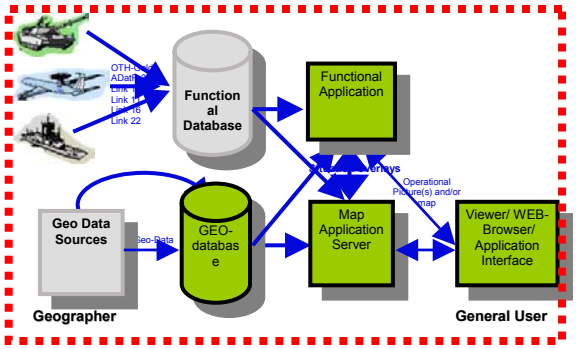

Figure 6. 3-Tier web based architecture of COP

COP is a helpful tool for the decision making. For this reason, according to the information requirements of the decision mechanisms, only the concerning aspects of the CCIS and theatre are projected on the screen. In fact "Common" Operational Picture reflects 3 dimension of the real theatre via recognized Maritime, Air and Land pictures, but concerning aspect is related to the command level of decision mechanism.

The data for COP comes from;

- ARP, MRP and LRP track/force element data.
- Information on forces (enemy, friendly & neutral ORBAT).
- Planning data.
- Historical data.
- Intelligence and logistics data.
- Geographic and meteorological data.
- Various CCIS data
- HTML data
- Tactical Data Links
- Formatted message data
- Military Catalogue
- Common Database

With the format of;

- OTH-Gold format
- ADatP-3
- Link 1
- Link 11
- Link 16
- Link 22

Briefly, optimized information should be geographically presented by COP; right on time, with sufficient detail and in correct form.

Situation awareness in COP does not cover real time data connectivity with sensor systems and weapon systems. Hence, situation awareness in COP, does not concern; real time image interpretation, target acquisition and weapon systems engagements.
Meanwhile, COP does not only serve for the decision mechanisms but also for the connected network users. COP, improves situation awareness of those about common view of the battle space, and belongs to a specific time period.
At the COP, the browser application is an interface that collects the data from different sources and combines them at the same picture as each "recognized picture" is an independent process that listens to database, sockets, etc for the info changed such as;

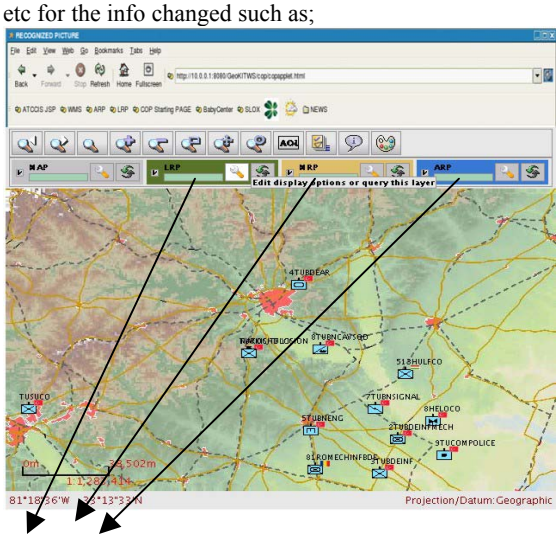

Figure 7. User specified filters of COP

At Each layer, the picture is assigned to user specified filter based listener for FAS and MAP databases via either direct or message based connection.

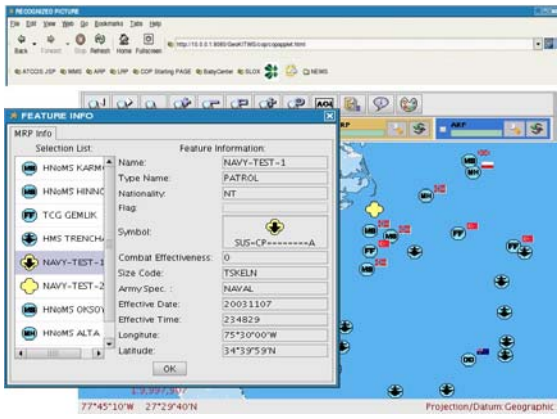

Figure 8. Feature query and information on COP

4. CONCLUSIONS

GIS is a specifically improved tool, in order to manage the digital geospatial information. In order to operate a GIS properly, there are some basic components. GIS has a wide potential in terms of application areas. One of the major GIS application areas is armed forces applications. At the beginning of the evolution process, GIS was a standalone tool. According to the last technical and strategic trends, GIS has become an integral module of CCIS. Most of the geospatial analysis capabilities and functional utilities of the GIS were developed and adopted to Functional Area Services of CCIS. Specific sub-modules have also been added. Standards for geospatial information, database architecture etc. were identified. Geo databases were established with a very wide spectrum of geospatial information. In accordance with the results of various tests and trials, the most effective architecture was identified as; **"WEB based GIS architecture with RDBMS based spatial data storage".**
With the implementation of these test results, some new applications have been developed such as COP. In the near future, connectivity, data integrity and interoperability will be the main issues of CCIS and GIS.

5. REFERENCES

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