FIELD INTEGRATED COMMUNICATIONS AND INFORMATION SYSTEM FOR BULGARIAN LAND FORCES

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Introduction

The development of command, control, communications and information systems is a priority in the development of the Bulgarian armed forces, established in the Governmental Program for NATO Accession [1] and confirmed by Parliament with the adoption of the Military Doctrine of Republic of Bulgaria.[2] In implementation of the declared priorities, the first major modernization project was for development of the field communications and information system of the main land formations of the Bulgarian rapid reaction forces, that would contribute to NATO and NATO-led peace support operations. The tender for the project, that became known as the FICIS (Field Integrated Communications and Information System) project was conducted in 1998. During its implementation requirements were influenced by the knowledge and experience gained by military leaders and experts during the comprehensive C4 Study,[3] as well as by dedicated seminars and discussions.[4]

The FICIS system has to provide NATO interoperability through advanced C2 capability of one mechanized brigade, one engineer battalion, one battalion for NBC defense, and one company for radiological and chemical surveillance. This article presents architectural requirements of the Bulgarian Land Forces that will be met by the FICIS System. Starting from an in-depth analysis of general requirements stated in the Technical Annex to FICIS Contract, the overall architecture of the system is developed and, at the same time, optimized to guarantee efficiency and flexibility. The article covers five main issues. First, we explain the technical reasons behind the contract negotiations in terms of number of telecommunication vehicles (stations), equipment, software packages and services. Secondly, clarifies the ways for connecting stations and their interfaces. The third part contains an example of Brigade deployment on the field. The fourth part of the article contains a brief

explanation of software and hardware devices for configuring and managing the network and the services. Finally, clarifies how the Command and Control applications work through the FICIS network.

1 Initial Requirements - Project Milestones

In this section, technical reasons behind FICIS architecture are briefly explained. The project milestones are listed with a brief explanation of the agreed solution.

Radio Access Points (RAP)

There are a total of four Radio Access Points in the system. This choice was made under both technical and operational considerations:

- When operating in stand-alone configuration, the brigade, the Combat Engineer Battalion (CEB), the Nuclear, Biological and Chemical Defense and Radiological Battalion (NBCDRB) and the Radiological and Chemical Surveillance Company (RCSC) can be assigned one RAP each, to support fixed to mobile and mobile to mobile communications needs. More than one RAP could be assigned to any mission (e.g. four RAPs can be assigned to the brigade);
- The necessity of having at brigade level more RAPs to support close-to-FEBA (Forward Edge Battle Area) operations has been partially reduced by providing the three mechanized battalions and the anti-tank battalion with a Mobile Command Post (MCP) equipped with a Light of Sight (LOS) radio relay to support multi-channel communications towards the brigade command post. It has been in fact recognized that connections with the battalions' subordinate units (companies, platoons, etc.) are established up to the battalions' commander, thus removing the need of direct Combat Net Radio Access (CNRA) connections to the brigade headquarter;
- .RAPs can indeed be used to increase the distance between the battalions' command posts (CPs) and the brigade CPs; in this case the Mobile Command Posts (MCPs) and Main Mobile Command Post (MMCP) represent the mobile users to the RAPs. This concept is applied throughout the system and at any command level;
- Each RAP supports three VHF radios and one HF radio; based on the data provided by HARRIS and considering the IP data application, each RAP can satisfactorily support up to 75 VHF mobile users and 25 HF users. This leads to a total capacity of up to 300 VHF Mobile Units (MUs) and 100 HF MUs. In the case of voice connections, the figures are not greatly affected if the average duration of a call is less than 30 seconds;

- Considering any one MCP/MMCP in the brigade as a potential MU to a RAP, and considering that only one VHF and one HF radios will be used to RAP affiliation, then the overall MCP/MMCP contribution equals to 46 VHF MUs;
- As for the sub-units, the overall number of radios is 456 VHF (excluding handheld radios) and only 32 HF vehicular or man-pack radios. It must be considered that only part of the CNR (Combat Net Radio) radios will be affiliated to the RAPs during real operations (due to user dispersion), or even that not all of them could be used at the same time (due to the resulting frequencies congestion that does not depend on RAP implementation).
- In conclusion, the number of RAPs (four) appeared to be adequate to the extension of the population to be served, to the traffic to be supported and even over-sized as for the HF application. It is recognized that the system can be scaled to population and traffic demand increase.

The Access Vehicles (AV)

The total number of Access Vehicles assigned to the Brigade depends on the requirement to provide Brigade Command Posts and Battalions' Command Posts with a WAN access point each.

Further two AV* (Access Vehicles or Extended Access Vehicles) are assigned to Main and Logistics Command Posts; also CEB, NBCDRB and RCSC Applications are provided with AVs.

The Transit Access Vehicles (TAV)

Only two TAVs are included in FICIS; both are assigned to the brigade.

Deployment of Single Channel Radios

A total of three VHF and one HF radios per RAP/MMCP and MCP are deployed to minimize mutual interference problems and to maximize the bandwidth exploitation.

Four mobile 400W HF systems are provided - one per application.

2 Interfaces

Many interfaces are used in the FICIS system in order to provide a complete, efficient, secure, and versatile network equipped with diverse applications and services.

Radio Relays

Two types of radio relay are used:

- *MH313/X:* Eurocom standard radio relay, band III extended (1350-2700 MHz), 2048 Kbit/s data rate;
- *MH344:* Eurocom standard radio relay, band IV (4400-5000 MHz), 2048 Kbit/s data rate.

Installed in Backbone Access Vehicles, these types of equipment guarantee meshed connections among FICIS digital switches (CD115E); such connections are made secure by using CM119 Bulk Encryption Devices.

Wired connections

Installing MT323/D Line Terminating Unit (LTU) inside Access Vehicles provides wired connections among stations. There are two types of channels:

- STANAG 4210 up to 512 Kbit/s;
- *Eurocom* C: up to 2048 Kbit/s.

As Radio Relays, also LTU are also used to provide connections among digital switches.

Single Channel Radios

Harris Falcon II VHF and HF radios aim to guarantee both connections between Backbone Command Posts and Subordinate Units (Sub-Units) Mobile Vehicles, and links among Sub-Units themselves.

- VHF: up to 16 Kbit/s for both voice and data, DTE channel for voice and Ethernet 10Base-2 for signaling and data in TCP/IP format;
- HF: up to 2.4 Kbit/s (600 bit/s hopping) for both voice and data, DTE channel for voice and Ethernet 10Base-2 for signaling and data in TCP/IP format.

CNR voice function is implemented through DTE channel connecting CD115E radio interface (DGTRAD board put into RAP vehicles).

CNR signaling is hosted by Ethernet interface directly passing through the Hub-Switch (included in RAP vehicles).

TCP/IP function in the radios is made by embedded hardware and software, so that the radios are directly connected to the Ethernet 10Base-2 line.

MMCP and MCP with Radio Relay vehicles, their digital switches CD115 being not equipped with DGTRAD board, cannot work as a "gateway" for voice CNR function, but they can also route TCP/IP packets thanks to routers installed in such vehicles.

Optical Link

Fiber Optic links are used to connect Hub-Switch, contained in vehicles, in chain way in order to make physical LANs working apart from the system, without taking resources from the WAN network.

This solution can improve system performance in two ways:

- By connecting many vehicles thus establishing high performance LANs (100 Mbit/s); this LANs will be homogeneous in terms of functions, operations, deployment, military hierarchy;
- By reducing traffic on WAN system, because LAN traffic is not routed through WAN if not strictly necessary. Only effective remote connection is to be made through the WAN.

External Interfaces

A pool interfaces to other networks is implemented in the FICIS System, at Access Vehicles (through Digital Switches).

- Eurocom "c" trunks with 16 channels at 16/32 Kbit/s according to the standard (256 and 512 Kbit/s)
- STANAG 5040 multi-channel analogue gateways
- STANAG 4206-4210 digital multi-channel gateway
- ISDN ETSI interfaces at 144 KBit/s (BRI to ISDN terminals)
- ISDN ETSI interfaces at 2048 Kbit/s (PRI)
- Analogue 2/6 wires analogue circuits to PTT networks or PABXs.

3 System Network Architecture

Different links are used depending on deployment requirements:

- Meshed Backbone
- Multi-channel radio links
- Optical links
- Wired connections
- Combat Net Radio networks

Also, Radio Access Point stations and Transit Access Vehicles are deployed.

4 Network Management

Since the FICIS System has a very complex architecture with different equipment and services, many network management packages are needed to cover all aspects.

Marconi NMS (Supervisory System)

At telecommunication equipment level, operations, network and equipment management is guaranteed by Marconi Supervisory System that applies to three different levels working together in a synchronized way:

- System Execution and Planning;
- Operational System Control;
- Facility Control.

The three levels can manage the entire telecommunication network from highest level, i.e., brigade deployment requirements, down to lowest physical detail, i.e., a specific board in any equipment.

The three levels run under SCO Unix operating system, on a dedicated computer family. Connections between supervisory nodes are established through the WAN system by means of gateway function realized by the general block identified as "Gateway".

This functional block represents CD115 Digital Switch and ATI-3100 Router joint functions.

The Routers route TCP/IP data trough digital switches that guarantee a meshed network.

Mapping this architecture with the brigade deployment, the two SEP (System Equipment Planning) posts are placed in the brigade Main and Logistics Commands. The OSC (Operational System Control) post is placed at the brigade's Deputy Command; in each telecommunication vehicle is placed a FC (Facility Control) post.

A Telephone Numbering Plan will be prepared and submitted to the user for discussion and approval.

NMS Operative Flow

The system can accept and manage maps in different formats. The system can manage encryption keys in conjunction with the KS119 Key Generation System included in FICIS.

System Execution and Planning

The SEP Rear post is aligned with the Main in order to be easily promoted to Main, when needed. The SEP level directly exchanges information with the OSC level.

Operational System Control

The OSC level directly exchanges information with both upper SEP and lower FC levels.

Facility Control

The FC level directly exchanges information with upper OSC level.

Microsoft NT™ Administration and Management

At information subsystem level (computers and peripherals), network administration is demanded to Microsoft NT™ administrative tools. Many services will be enabled in the system in order to facilitate and to make automatic complex and boring activities.

Primary/Backup Domain Controllers and Resource Servers will be placed in the system in such a way to guarantee best performance and balanced use of communication channels (WAN system).

User Account will be managed under in respect to Microsoft constraints; management will be open for all relevant aspects as groups, permissions, rights, sharing resources, priority.

DNS and WINS services will be enabled to automatically resolve IP addresses from computer names.

DHCP service will be enabled to allow centralized automatic management from the brigade Main Command.

A *Private Network IP addressing model* will be adopted to make the network flexible and to guarantee coverage of necessary devices. An IP addressing plan will be created and submitted to the user for discussion and approval.

A specific software package [5] is to be adopted for easy monitoring of network status, in centralized manner.

Five Firewalls, included in FICIS (two assigned to the brigade Main and Logistic CPs, one for CEB, one for NBCDRB and one for RCSC), will be set up in *Bastion Host* configuration, for better protection of secure access from/to outside FICIS, allowing flexible and centralized monitoring and configuration.

Routing Techniques and Router Administration

Routers' configuration and monitoring can be made in two ways.

- At power-on, routers will start in a brigade standard (pre-defined) configuration option, that will allow each router to be basically connected to the WAN system through local digital switch; then a centralized operator (i.e., at SEP level) can modify configuration of each router to accomplish mission specific requirements;
- At start-up, also predefined routing algorithms will be loaded automatically by routers to establish the meshed network.

Some static routes will be put (manually or automatically) for defining into routers the right paths for linking Mobile Users.

Single Channel Radios Administration

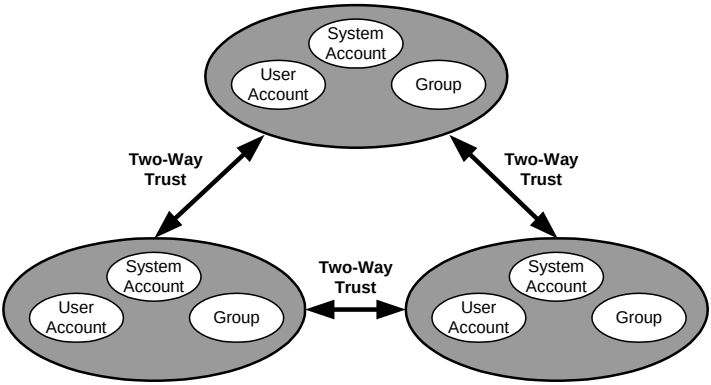
VHF and HF Radios will be configured by means of VHF and HF Network Management Software, that is Harris Radio Programming Application™ software package (RPA). Each radio will be defined as a "net member" using RAP. Then the operator will upload each radio with proper configuration file.

The RAP software runs on CNRA Station and flows over Ethernet.

5 Command and Control Architecture

Operating system

The operating system for the Command and Control will be Windows NT. There is no strict relation between NT Server and Command and Control Servers or between NT Workstation and Command and Control Workstations. The Model for the definition of Windows NT domain is named *Complete Trust Model* shown in following figure.[6]



Database Management System

The Database Software Package for the RDBMS is ORACLE; the data model will be the Generic Hub 3.

The Data Base architecture is based on the following principles:

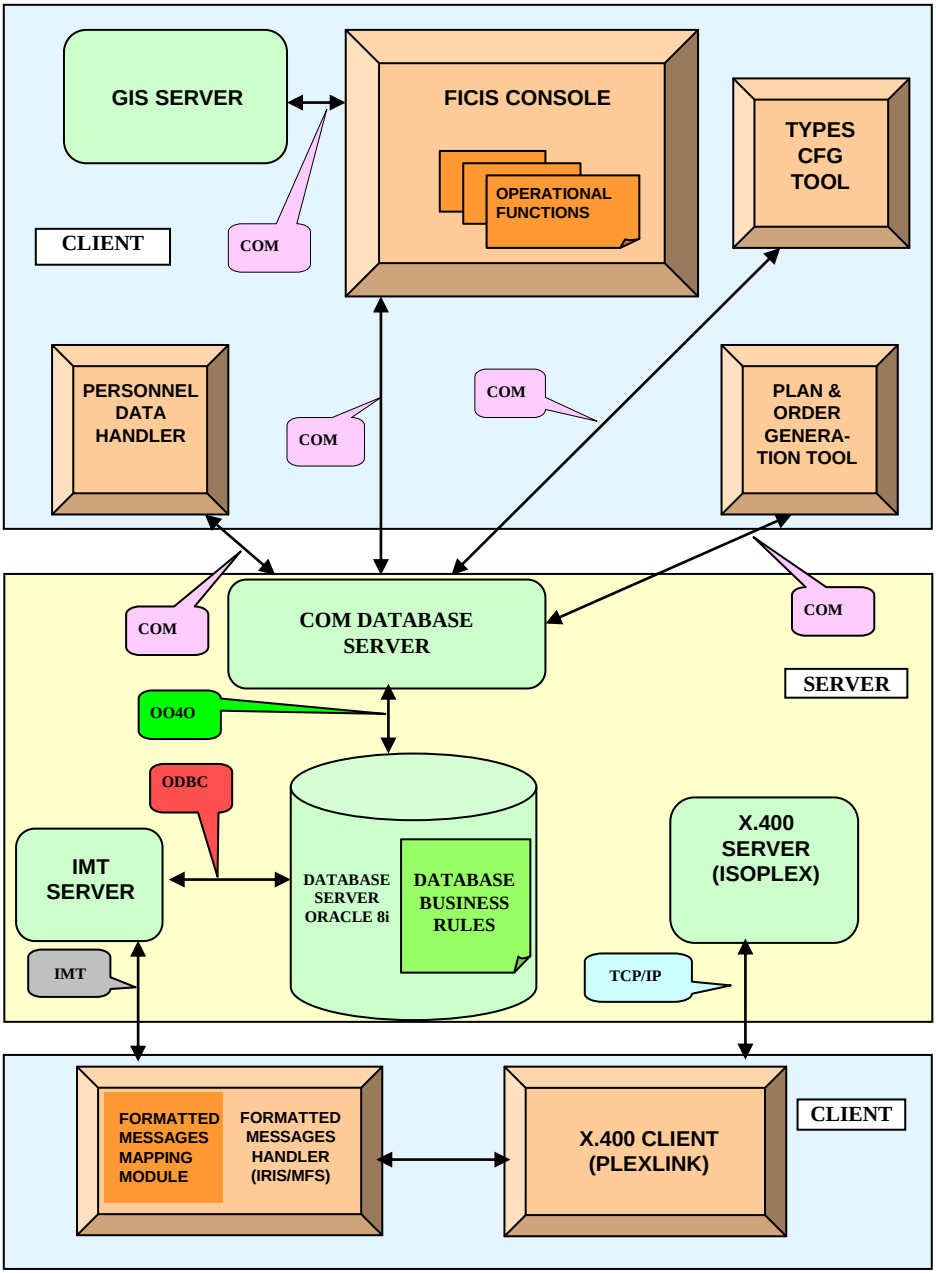
- Each CP LAN has its own "copy" of the Operational Database, resident on the CP server that stores all the information about the RLP (recognized land pictures).
- All databases share the same data model (based on the ATCCIS GH3 data model).
- Each workstation has its own local working area (private DB) to perform its activities (plan preparations, line of action evaluations, etc.)
- A replication mechanism ensures that the Database of all the CPs are maintained aligned on transaction basis.
- The replication mechanism takes care, in case of network failure between two nodes, to store transactions.
- The replication mechanism will maintain aligned the CPs' Databases, if they are connected by a LAN or by a WAN provided by sole users' circuits.
- The replication mechanism will maintain aligned the CPs' Databases on user request, if they are connected by a WAN provided by radio channels.
- The software package for the data management will be the Oracle Administrating Tool.
- The role management functions will be provided by a software package delivered by Marconi.

Geographic Information System (GIS)

ESRI Map Objects and ESRI Arc/View compose the software platform for GIS applications (with the extension of "Spatial Analyst" and "Network Analyst" in the workstation).

- Map Objects will be used for the core application (FICIS Console) that will provide the user the basic GIS functions.
- Arc/View and its extensions will be used for the enhanced GIS functions, it will work in addition with the application based on Map Objects.

The *FICIS Console* is the main CCIS (Command & Control Information System) application (see the figure above). FICIS Console is the starting point for each specialized function, for example NBCDRB, Logistics, Office & Multimedia, GIS enhanced functions and so on.


GIS SERVER
FICIS CONSOLE
OPERATIONAL FUNCTIONS
TYPES CFG TOOL
CLIENT
COM
PERSONNEL DATA HANDLER
COM
COM
PLAN & ORDER GENERA-TION TOOL
COM
COM DATABASE SERVER
COM
SERVER
OO4O
ODBC
IMT SERVER
DATABASE SERVER ORACLE 8i
DATABASE BUSINESS RULES
X.400 SERVER (ISOPLEX)
IMT
TCP/IP
FORMATTED MESSAGES MAPPING MODULE
FORMATTED MESSAGES HANDLER (IRIS/MFS)
X.400 CLIENT (PLEXLINK)
CLIENT

Message handling System

The software package for the Message Handling System is ISOCOR ISOPLEX; each server CP will have an ISOCOR X.400 MTA; each workstation will be connected to the X.400 MTA server through the User Agent software.

Each User Agent will provide the client workstation the following capabilities:

- Send/Receive e-mail using the COTS ISOCOR PLEXLINK
- Send/Receive formatted AdatP-3 messages using the COTS ISOCOR PLEXLINK in conjunction with the COTS IRIS/MFS.

Office Automation

The COTS for the Office Automation are the following:

- Microsoft Office Professional;
- Apple Quick Time 3 pro for Windows NT;
- Corel Photo Paint 8.

They will be provided on node basis.

Conclusion

FICIS Project is expecting to be deployed in the Land Forces in April – May 2002. During the 18-month warranty period the system shall be observed very precisely. According the results from this period the engineers will to trace out the best feature use of the System and the ways for its exploitation and improvement. The combat effectiveness of the units using FICIS has to be evaluated and compared with others that do not use digital Communications and Command & Control Systems. Such kind of independent assessment can be done if the units using FICIS take part in NATO exercises or in combined military formations and operations.

Notes:

1 *National Program for NATO Accession* (Sofia: Council of Ministers of the Republic of Bulgaria, February 1997).

2 *Military Doctrine of the Republic of Bulgaria*, Approved by the XXXVIII National Assembly of the Republic of Bulgaria on April 8, 1999, (Sofia: Military Publishing House, 1999). Full text in English is available at http://www.md.government.bg.

[3] *C4I Study for Bulgaria: Final Report* (USAF ESC/MITRE, January 2000); *C4I Study for the Ministry of Defense of the Republic of Bulgaria: Comprehensive Analysis and Assessment of Ongoing Projects and Legacy C4 Systems and Estimation of the Level of NATO Interoperability* (Sofia: Military Publishing House, 2000).

[4] The readers may refer to Loren Diedrichsen, "Command & Control: Operational Requirements and System Implementation," *Information & Security. An International Journal* 5 (2000), 23-40; Charles R. Myer, "C4ISR Architectural Frameworks in Coalition Environments," *Information & Security. An International Journal* 5 (2000), 60-72.

[5] Hyena by Adkins Resources.

[6] *FICIS Project. System Design & Operational Guidelines* (October 2000).

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