INSTITUTO SUPERIOR TÉCNICO, DECEMBER 2019

Radio Over IP (RoIP) Communications Management and Control System

Pedro Miguel Martins Leitão da Costa, 78153, MEEC

Academia Militar / Instituto Superior Técnico

email: pedro.da.costa@tecnico.ulisboa.pt

Abstract— Currently, the Portuguese Army has the military transceiver GRC-525 Multifunctional Radio which equips the tactical units within the operational component of the ground forces system. This equipment provides to the ground forces the ability to establish secure communications. The current version of the GRC-525 Multifunctional Radio provides a transparent integration with IP data networks and specifically with IP telephone systems through SIP protocol.

The GRC-525 Multifunctional Radio allows bidirectional radio voice calls, however the confidentiality and simultaneity of communications are not assured. This happens because the communication is established over shared radio frequency and on a given radio network at a time and only one user can transmit the message while the others are only in reception mode (half-duplex system).

To solve these limitations, was developed Radio Over IP (RoIP) Communications Management and Control System, which allows users at a command post to establish a call with any entity that is carrying out its operational activity operating with the Radio Multifunctional GRC-525, regardless of the radio network it is in, ensuring the confidentiality and simultaneity of communications.

The present system has other features, among which are the recording of all calls to allow backbriefing, as well as the creation of a history with all events resulting from actions performed by the entities that use it (such as: entry and exit in the application, outgoing calls, etc.).

Index-Terms — Portuguese Army; Radio Multifunctional GRC - 525; Radio Over IP Management and Control System.

I. INTRODUCTION

Regarding the military telecommunications networks, these have significant importance in our society. They stand out because they can operate independently of civilian communication networks and can be used to support the population in the event of disasters or crisis, as well as to support and control our military forces when they are operating abroad in Theaters of Operations (TO) to accomplish their mission [1].

In the current organization of the Portuguese Army Tactical Communications System, when deployed in missions, whether in national or international territory, is structured as follows: there is at least one Command Post (CP), where are the commanders and network managers who follows the maneuvering forces deployed at the TO. These elements constitute the tactical network based on IP technology.

In order to grant radio communications between the forces within the command post and the forces engaged in the TO performing the tactical tasks, the Army Deployable Tactical Communications and Information System(SIC-T) has a specific communications module named Radio Access Point (RAP), which provides integration between the radio networks and the SIC-T IP data network., acting as a radio communications gateway [1], as it is possible to observe in the figure 1.

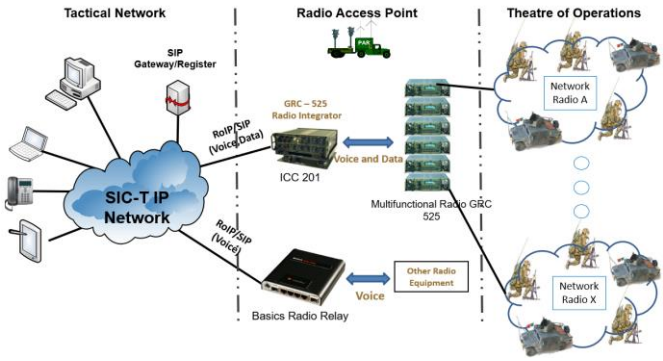

Figure 1 – Integration between the SIC-T IP network with the radio network

The RAP is a military tactical vehicle that carries a communications shelter equipped with communications assets, autonomous energy support systems, namely through an electrical generator, as well as the possibility of interconnection with external power sources. In fact, the RAP plays an important role in

the development of this dissertation and therefore, this SIC-T communications module will be discussed in more detail later.

A. Limitations of the actual Situation

Despite the RAP communications module, allowing integration between the GRC - 525 multifunction radios and IP protocol based telephony (call establishment between the control station and a specific radio operator equipped with the GRC - 525 Multifunctional Radio), this mechanism presents some tactical limitations:

The RAP module allows up to six simultaneous communications on separate networks, these are half-duplex and PTT communications. However, in a situation where all channels are busy there is no system for call management and prioritization. In a scenario where an element on a given CP wants to communicate with someone in the lower echelons and this communication takes precedence over the communications already in progress, there is no call manager that terminates one call with lower precedence and allows the establishment of the new communication with higher precedence.

At the level of radio users, which are elements operating from tactical vehicles or pedestrian equipped with the GRC-525 Multifunctional Radio, are able to communicate with the upper echelons through a previously designated or defined radio network. It's not possible to guarantee the confidentiality of communication between the parties involved in the communication, since all other elements belonging to this radio network can listen the communication. In this scenario, a mechanism to signal the communication is needed, in order to inform the originator of the call, which channel he can use for that specific communication.

Earlier solutions of the RAP where provided with a data terminal attached to GRC-525 Multifunctional Radio provided to the radio users in order to receive signaling information with the procedures to be followed before and during voice communications [2].

B. Objectives

This Master's Thesis aims to develop a Radio Over IP (RoIP) Communications Management and Control System that dynamically and efficiently allows monitoring, Management and Control System of communications between radio networks and IP networks, implementing the RoIP concept.

This system should also ensure the selectivity of calls between the command post and the particular entity in the theater of operations, to avoid to broadcast communication and to occupy the entire radio network thus ensuring efficiency and confidentiality of communication.

It is also intended to provide the Radio Over IP Communications Management and Control System with the ability to create a record of call details.

C. Proposed Solution

The GRC - 525 Multifunctional Radio has a remote-control feature when integrated into the IP network through which external applications can place requests to the radio via commands without the need of an operator. These requests include: getting the preset channel on the radio (preset page - PP), sending Short Data Messages (SDM's) and getting the list of participants in the radio network.

As mentioned earlier, RAP allows up to six simultaneous communications on separate networks, of which four allow for phoning and data and the other two are used for phoning only. In RAP, all radios will be connected to the SIC-T's tactical IP data network.

According to the needs of the mission there should be at least one radio equipment of the six in the RAP intended for the establishment of peer-to-peer communications, this is, between a PC entity and another battlefield entity.

II. RELATED WORK

A. Tatical Communications

Everywhere in the world, the military forces face challenges that are increasing difficulty. The current operating environment is characterized by its complexity and it is in these scenarios that the military must be prepared to act, as well as their communications systems. Therefore, information and communication systems should provide timely and effective access to the information to facilitate the decision-making support. In order to reduce uncertainty on the battlefield these systems must ensure information superiority, which is a key requirement for the mission accomplishment [3].

The SIC-T is a modular system of an adaptive nature that connects from the lowest echelons of command to the top command structure of a military force, in a secure, flexible and efficient manner. For this reason, it is called a tactical system because it follows and supports the tactical force when in a campaign situation, as can be seen in figure 2.

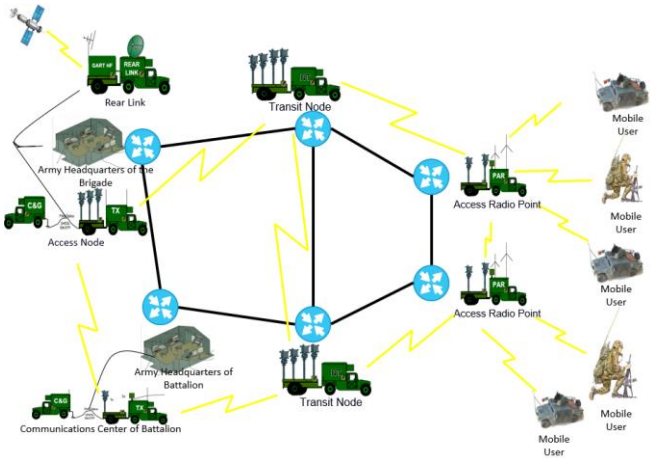

Figure 2 - SIC-T Architecture

B. GRC-525 Multifunctional Radio

The GRC-525 Multifunctional Radio is a tactical transceiver that currently equips the Operational Elements of the Land Forces System (ECOSF) in various versions (manpack, vehicular and fixed station) [4].

With regard to security, the GRC-525 Multifunctional Radio enables very effective communication security (COMSEC) through an encryption mechanism, as well as transmission security (TRANSEC) with its frequency hopping capability [4].

Regarding its operating band, the GRC-525 Multifunctional Radio operates in a frequency range from 1.5 MHz to 512 MHz, covering the HF, VHF and part of UHF frequency bands. The fact that this tactical radio is Software Defined Radio (SDR) makes it possible to update it through software and new features can be added without changing the hardware. It can be configured for operation via configuration software or manually [4].

This radio has the ability to operate in local area networks (LAN) or Wide Area Networks (WAN). The current software version allows integration with IP telephone systems using the SIP protocol. The radio also has two modes of operation that employ the frequency hopping mechanism, namely SECOM-H mode in the HF frequency band and SECOM-V mode in the VHF and UHF bands [5].

C. VoIP

VoIP (voice over IP) technology, currently used globally, enables the transport of voice signals using the IP protocol.

VoIP can be used on any IP data network, such as the Internet and LAN. Its employment has grown over the years, due to its flexibility and cost efficiency and the fact that it is supported on packet switching networks and therefore does not require dedicated physical circuits. Its use has also been found in Internet-based communication applications, such as some social media (WhatsApp, Facebook Messenger,…), as well as at the organizational level with their implementation in telephony systems based on IP networks.

Data processing in VoIP takes place as follows: On the sender side, analog voice signals are converted to digital signals, compressed and then placed into a specific format using a voice codec, such as: G .711, G.729 and G.723. The coded voice will be divided into packets of the same size, to these packets will be added RTP, UDP, IP headers and the data link layer header.

D. VoIP in the Radio Multifunctional GRC-525

The GRC-525 Multifunctional Radio has the functionality of VoIP service. This feature allows the establishment of voice communications with a VoIP user, such as a VoIP phone that is present on the IP network [6].

In addition to this feature, the radio also has a remote control capability, which can also be used when the radio is operating with active VoIP service.

In a radio network there is a radio that is configured as a VoIP gateway radio and the radio is connected via Ethernet to an IP network. This configuration allows the establishment of calls from a VoIP telephone to the radio network, through the gateway radios. The remaining radios in the network that are only interconnected by radio frequency are called endpoints. To configure the radios as gateways or endpoints, the Mission Planner application is used [6].

III. REQUIREMENTS OF THE ROIP MANAGEMENT AND CONTROL SYSTEM

A. Safety Requirements

SR1 - SECOM radio communication;

SR2 - Authentication in the application;

SR3 – Different levels of access to the information;

SR4 – Integrity of the system information;

SR5 - The system must be based on HTTPS protocol.

B. Functional Requirements

FR1 - Using VoIP telephone as a communication terminal in a command post;

FR2 - Long communication distance;

FR3 - Creating an event history;

FR4 - Make private calls;

FR5 - Fast and interactive way to establish communication;

FR6 – No human intervention in the RAP.

C. Interoperability Requirements

IR1 - Integration of radio network with IP network;

IR2 - Radio network integration with VoIP network;

IR3 - Interaction with the GRC-525 Multifunctional Radio through a web application;

IR4 - Integration of PTT model in VoIP telephone system.

D. User Classes

The RoIP Management and Control System provides different features that may not be available to all types of users. There are out two categories of users for this application: the Administrators and the Operators.

1) Administrators

This category of users consists of the administrators of the local network of SIC-T, which team is responsible for all maintenance and implementation of the RoIP Management and Control System.

This team has several functions, such as the configuration of radios. As mentioned in previous sections, radios can be configured as gateways if they have access to the IP network and where they can be integrated with the VoIP service, or they can be configured as endpoints, which are inserted into a gateway's network using radio communications. Still related to the configuration, the elements of the SIC-T are also responsible for assigning other parameters on the radios, such as the IP data network to which they belong, preset pages, frequencies, waveforms, among other parameters.

These settings vary according to the needs of each mission and are introduced in Mission Planner software.

Administrators are also responsible for controlling access to the application, as they register operators who will be present on certain missions, giving them the credentials necessary to log in the application and the telephone extension that interconnects directly. with the login user.

Also associated with this category, only administrators are allowed to access the application's event logs, as well as the access to the files where dialed calls through the application are recorded.

2) Operators

This user category is for users on the CP which are assigned with a computer and a VoIP phone.

The registration of the operators and the distribution of authentication credentials is the responsibility of the administrators. As soon as the operators have the credentials available, they are able to login to the application and the phone that they have assigned to them must be already active and interconnected with the system.

This category has the ability to make calls directly to a radio network or make private calls with specific entities within a radio network that is in the TO.

IV. ARCHITECTURE

Regarding the architecture of the RoIP Management and Control System, it is inserted in the CP, belonging to the tactical network and is connected to the user through the browser. It also interconnects the IP PBX, specifically Asterisk, which is configured each time a new tactical mission takes place. This architecture has been developed to meet the requirements defined previously.

The numbered connections (figure 3) will be explained in more detail below, in order to understand which protocols are used and the type of data that is transferred between each component of the architecture.

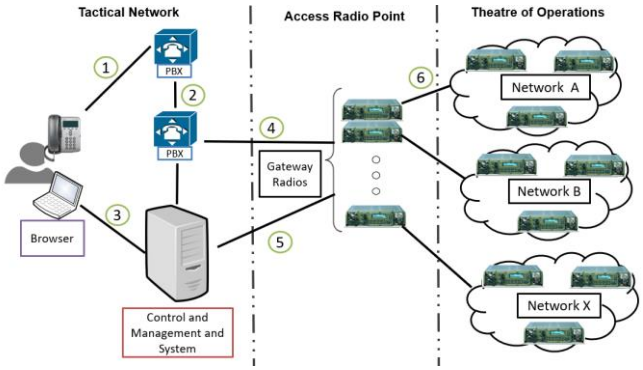

Figure 3 - Introduction of the RoIP Management and Control System in the SIC-T Architecture

On connection number 1, the SIC-T VoIP phones are all registered in the PBX, Call Manager Express [7].

In connection number 2, a SIP trunk is made to interconnect the PBX used by the SIC-T and the other IP PBX where the phones used for a mission are registered, thus allowing communication between entities outside the operating environment, for example. a military in Lisbon can communicate with a military deployed in the TO, in Afghanistan.

In connection number 3 uses the HTTPS protocol, which allows the browser to run the RoIP Management and Control System securely.

In Connection number 4 concerns voice, where the Management and Control System PBX is responsible for ensuring the exchange of voice messages between CP and external phones, as mentioned in connection number 2 communicating with the military in the TO, using protocols, like SIP and RTP.

The Connection number 5, is based on the control administered by the RoIP Management and Control System to the GRC - 525 Multifunctional Radios, present in the RAP (gateways), making the remote control by establishing a connection, using TCP Sockets, and sending commands via the API for radio remote control [8].

Finally, link 6 is concerned with the transmission of radio frequency information between radios present in the RAP (gateways) and radios in the TO, the endpoints, where each GRC - 525 Multifunctional Radio installed inside the RAP can be detached to a radio network or to provide private calls between the upper echelon and the military in the TO.

In the next figure (figure 4), shows a more focused view of the RoIP Management and Control System developed, where it is possible to observe all the modules that it comprises: the Communication Control Module, the Activity History Module, the User Manager Module and the Radio Control Module, as well as how they interconnect with the external elements of the System. Then we present and explain the function of each of these modules.

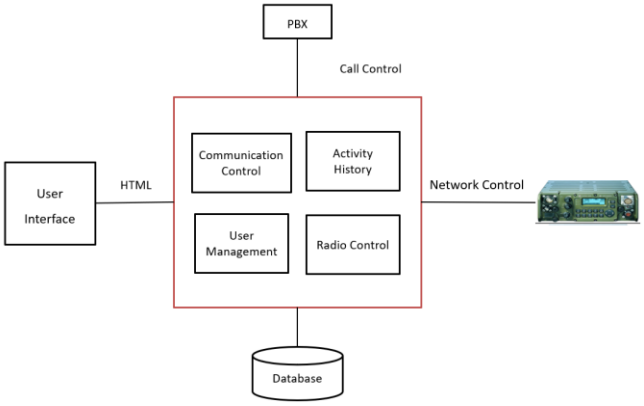

Figure 4 – Architecture of the RoIP Management and Control System

The Communication Control Module is the module responsible for all communication of the System, bridging the protocols of the GRC - 525 Multifunctional Radio and the phones used in the CP, in order to allow the communication between them.

Regarding the Activity History Module, it is responsible for recording all events that a user performs through the RoIP Management and Control System, from simple Login/Logout, to the establishment and termination of a call, as well as recording. of the same.

Regarding the User Manager Module, this module is intended for System administrators, they configure it, either on the CP users side or on the radio networks side, which are responsible for giving users access to a mission and for creating the radio networks necessary for that mission as well.

Finally, the Radio Control Module has the function of controlling the radios in the RAP connected by IP, through the functionality that they have, remote control, allowing the establishment of VoIP calls, sending messages, access to the list of network participants, among others, without the need for human intervention.

All of these modules are linked to a database where the information concerning with each one is stored.

V. SYSTEM EVALUATION

A. Safety

SR1 - The configuration of all radios used in missions implemented in the Management and Control System are in SECOM-V/U mode, if operating in the VHF/UHF band, or SECOM-H, if configured in the HF band, depending on the frequency band for which they are programmed to operate, thus enables safe communication and frequency hopping.

SR2 – In order to obtain access to the system, the users must authenticate themselves first, by completing the login fields: Email and Password. In addition to this method, it is also possible to integrate the System with other authentication mechanisms, such as Lightweight Directory Access Protocol (LDAP) or centralized authentication systems.

SR3 - Regarding the level of access, the Management and Control System, divides the user group into two categories, operators and administrators, each having distinct levels of access to the features of the System.

SR4 - This Requirement is not only directly connected with the System itself, but also with radios that may affect its proper functioning. Regarding the service provided by the radio, integrity

may depend on the distance between the radios in the RAP and the radio operators in the TO.

SR5 - The RoIP Management and Control System runs over the HTTPS protocol, ensuring that data is transmitted over an encrypted connection and verifies server and client authenticity through digital certificates. For field testing the System was not integrated into the SIC-T Data network, running on a specific testing network. However, it is thought to be inserted in the network, in order to place another layer of security provided by that network.

B. Features

FR1 – RoIP Management and Control System has the ability to integrate the telephone network with the radio network, and it is possible to establish the VoIP connection between the gateway radios present in the RAP and the phones available on the CP. In addition, the system configuration introduces the PTT protocol on the phones. Thus, as shown in the requirements, the number of radios installed at the control station is reduced while maintaining the safety level.

FR2 - This requirement is met as the radios present in the RAP are integrated into the SIC-T network, making it possible to carry out long distance communications between system operators at the command post and radio users at the operation theatre. With this system it is also possible to make calls from national territory to a given theatre of operations, if the user wishing to make the call is integrated in the Army data network and registered in the System PBX, or registered in an Army PBX where it is possible to perform a SIP trunk.

FR3 - One of the great features that comes with the development of the application is the emergence of a mechanism that allows to record all events that are performed through it. Thus, all messages, calls and logins / logouts are logged in the application, and access to this feature is only allowed to administrators, who can access the traffic that occurred for a given mission using the System.

FR4 - The present Management and Control System introduces another novelty which until today could not be realized through RAP, the fact that a mechanism has been created to make private calls between an entity on the PC and a radio operator on a radio network. In the figure 5, is shown how a CP user can choose between the entities inside of a radio network, whom he wants to call.

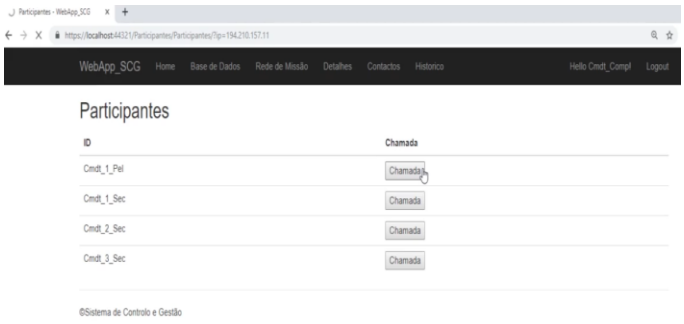

Figure 5 - User access to a radio network participant list

FR5 - Application users can quickly and interactively view all networks that are in operation and all elements of them, thus being able to make a call with these users if they wish, without having to know the extent of it as it is mentioned in SR3. This code varies by mission (requiring only data to be changed in the System).

FR6 - The System has been developed taking advantage of numerous features that the GRC - 525 Multifunctional Radio offers by highlighting the remote control, made from a connection made through TCP Sockets, when it is integrated in the IP network.

C. Interoperability

IR1 - For the integration mentioned above, the Portuguese Army has the ICC-201 system. This is a robust equipment that allows to connect up to six radios to the IP network. This device is installed in the RAP, and is directly connected to the System, controlling the entire flow of information.

IR2 - The System meets this requirement as all gateway radios that make up the System are configured with VoIP mode and are also registered with the Asterisk - PBX used for System development. These radios, acts as a bridge between the "world" radio and the "world" of IP telephony. This integration allows a user on the CP to dial and establish a connection between its VoIP phone and a specific radio network.

IR3 - After analyzing all the advantages that web applications present today, it was decided to develop the system based on web services, in order of taking advantage of the best user experience and the features that it offers.

IR4 - This requirement is implemented, the telephones used follow the established protocol to make the communication, that is, when the user wants to make a transmission presses once the key “1” of the telephone, symbolizing that the transmitter is pressing the PTT (broadcasting), and when he wants to finish his transmission, he must press the “2” key of the phone, symbolizing

that the user has released the PTT. This mechanism allows users to comply with the communications discipline imposed on military communications.

D. Field Testing

During the period from 9 to 10 July 2019, during the third Military Training Block (MTB3) of the Military Academy, some tests were carried out to verify if the developed System was capable of accomplish with the requirements. It was a mission to check its ease of implementation and if it was user friendly for users operating in this scenario.

The system was integrated and tested during the military exercise "LEÃO 19", which took place at the military training area of Santa Margarida. The main objective for this exercise is to provide the essential operational knowledge and skills to the students while operating the military assets available within Portuguese Army in a operational context.

For the first phase of the tests it was necessary to configure the Mission for this specific exercise through the Mission Planner software. This software is used to introduce the radio's IPs, frequency assignment, preset page definition, among other configurations. After all settings are completed the mission is loaded into a Fillgun, and then updated on all radios involved in the mission.

There were three fundamental positions: the CP (figure 6), the RAP, which is possible to observe in the figure 7, and the Radio operator deployed in the TO, shown in figure 8.

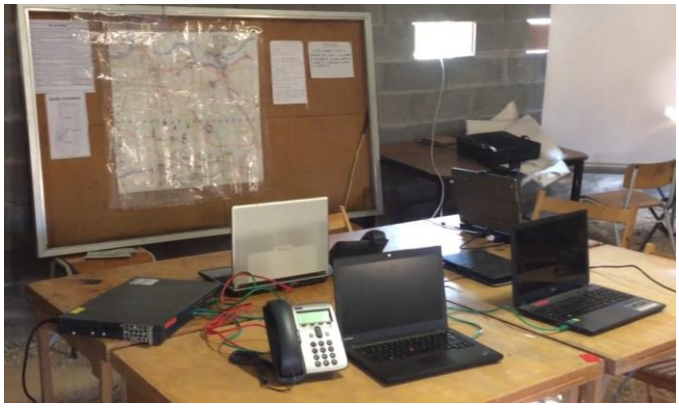

Figure 6 – Command Post of the "Leão 19"

.

Figure 7 - Radio Access Point deployed in the "Leão 19"

Figure 8 - A deployed military in the theatre of operations

On the second phase, the phones were tested, configured and assigned to the entities present in the CP. In addition, they were registered in the IP PBX, the System database and the gateway radios as well. After all these procedures were completed, this phase finished with the verification of the system, by establishing test calls between a user at the CP and a radio gateway installed and configured inside the RAP. This test had its main purpose to verify whether it was possible, to establish the call between the CP user and a particular radio network through the System. This phase was successfully completed, and it was found that all elements present in the network were able to listen and participate in the communication.

The third phase began when a CP user, using the application, dialed to call a radio operator deployed in the TO with a GRC - 525 Multifunctional Radio. This phase was also accomplished successfully. Regarding the dial and call establishment delay, the factor that can most significantly contribute to this whole process

is the response time of the radio operator to the received SDM. However, if the radio user has become more familiar with the radio operation, the call between these two entities will be established within a short time. The tests performed demonstrate that the RoIP Management and Control System is practical and useful tool to be implemented in military operations.

E. System Validation and Presentation

The work carried out consisted in the creation and development of a Call Management and Control System based on the GRC - 525 Multifunctional Radio. The System is intended for all categories of users, although each one has different roles in terms of System users and radio operators. Because this is a research project, the opinion of subject matter experts in the area was verified, through presentations about the overall system inside the Military Academy and in the Logistics Command Support Unit, where the Army CIS Directorate Engineering Support Team for the development of SIC-T project is located.

These presentations were made in order to explain the motivation of the choice of the theme, the limitations of the existing system related to this theme, the concept and scheme of the proposed solution and the practical demonstration of the developed features of the RoIP Management and Control System as proposed as a solution.

At the end of each presentation explaining the scope of the work developed, questionnaires related to the System were presented and explained. The questions are essentially scale questions ranging from 1 to 5, so that the focus is on the features of the System and the respondent can give an opinion on their usefulness, thus allowing to verify how the RoIP Management and Control System has proved a contribution to the Portuguese Army.

The entire population surveyed stated that the system allows to solve problems that were previously a limitation and proved to be a valuable contribution to the Portuguese Army. The same was no longer true when asked about implementation in future military operations. This topic has been much discussed as the System is ready to be implemented, but it would be preferable to improve it and go further beyond its functionality, adding other capabilities that will be proposed in the last chapter on future work to further enhance this System.

However, it has been found that once implemented, the Portuguese Army will have a tool that will bring much value to the current tactical radio communications processes.

With the respondents' answer to the question regarding the ease of use of the System, the requirement is met as the answers were positive as they ranged from level 4 to 5 on the scale of 1 to 5, as it is possible to see in the figure 9.

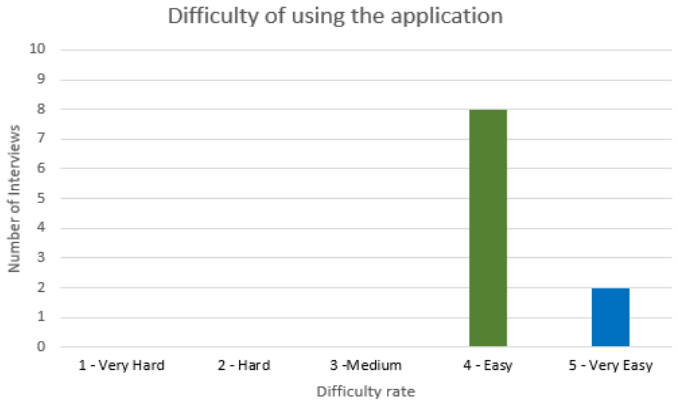

Figure 9 - Graph with response about the system ease of use surveys

Regarding the answers obtained about the features, they prove the relevance of the capabilities that the system provides. After an overview of all aspects assessed, it can be seen that there was an equality regarding the predominance of levels with regard to level 4 and level 5 in the defined utility scale, shown in figure 10 and 11.

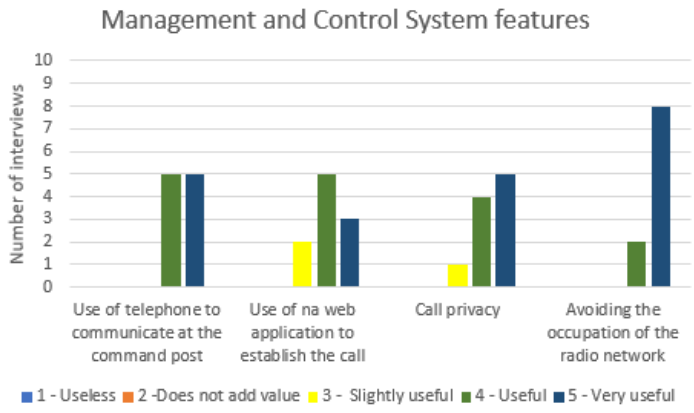

Figure 10 - Graph with response about the Management and Control System features

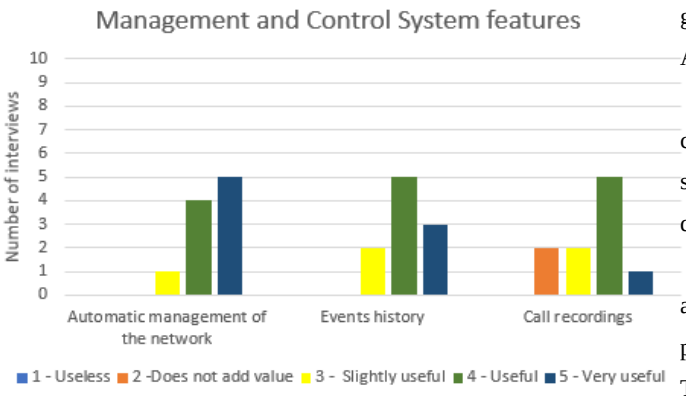

Figure 11 - Graph with response about the RoIP Management and Control System features

Thus, it can be said that both, the privacy of calls, the ability to not occupy communication on a radio network, and the automatic management of network use, are features that respondents can classify as indispensable in the System.

The call recording can also be seen that the majority of respondents considered this to be a useful factor in the system particularly in post-debriefing after military operations.

VI. DISCUSSION

The system has numerous advantages, among which stand out the confidentiality of calls between two individuals, one of which is on the CP operating the system and the other fulfilling its mission in the area of operations. The creation of an activity history in the system was also a great feature that gives lots of information about who is operating the system and about the actions that they are developing.

Through the surveys conducted it was found that the features provided by the System are useful and added a huge value, as they did not exist in the Communications Systems in the Portuguese Army. In addition, the system has the capacity to manage the network, this is, the system independently checks the status of the radios, the elements available in their radio networks, the flow of messages sent by them, the status of phones on the CP, among others.

Although all the valences that the System brings with it, as far as its applicability is concerned, it is now ready to operate, as it was observed in the field tests that took place in exercise “LEÃO 19”, at MFB 3 of the Military Academy. However, it would be more useful if it were improved and added more features that will give it more value and potential to become part of the Portuguese Army's communication systems in the future.

The web application is a factor that has made a very positive contribution to the system as it does not need to be installed on a specific operating system but is only dependent on access to the IP data network.

The use of the SIP trunk also adds a lot of value to the system, as it introduces the possibility of interaction also between military personnel who are in the national territory with mobile users in the TO.

For the implementation of the System the two integrators were tested, ICC - 201 and Vocality Basics Radio Relay. It was verified that the first one fit better in the operations in which the System was applied, since ICC-201 , was developed exclusively for the GRC - 525 Multifunctional Radio, offering extra capabilities (compatible with the radio remote control protocol, integration of phone and data in different radio operating modes, increased resilience to noise related interference, among others…) that Vocality Basics Radio Relay does not provide, as this equipment was developed to integrate different types of radio only through the audio interface. In addition, the ICC-201 also offers greater flexibility in the number of radios that can be used as a gateway, however either of the two integrators has the possibility of being scalable.

The System, also minimizes the need for its users to know which extensions to dial in order to place the call with the radio networks, since all of these are registered in the System, and it’s not necessary to make the call to the extension, but select option with the entity in the System that he wants to contact, and since calls go through the system. The system is able to keep track of them and save the details that relate to them. This way, only administrators have access to the call signs of the radio networks, increasing the security level of the communications.

VII. CONCLUSIONS AND FUTURE WORK

With the framework presented, in the first chapter, the importance of communications in an operational environment, where the soldiers are present in risky and emergency situations, and security is a key issue to be taken into account. As such, the Portuguese Army Engineering Support Team for the SIC-T project carried a study in order to analyze the current situation, raising

some limitations of the RAP module, then presenting the proposed solution to overcome the limitations described.

A solution has been developed to implement a Radio Over Communication Management and Control System., with the intention of being a tool with great utility and suitable for operational employment in the land forces.

Firstly, efforts were made to mitigate the limitations previously raised, in order to develop the solution mentioned above, starting with the definition of the requirements according to the existing needs, from which the architecture, the data model to be used and the execution flows are analyzed. The system was implemented and set forth.

In a second analysis, after the implementation of the System, tests and evaluations were defined and executed, where the System properties were compared with the defined requirements: regarding security, it was verified that the respective requirements regarding the functionalities, it was found that its development and application proved to be a success. Finally, as far as interoperability is concerned, the System has integration capabilities with other systems that are addressed in the interoperability requirements.

The verdict of accomplishment of the objectives materialized itself in a RoIP Management and Control System, with functionalities that until then had only been thought, although they are of great importance, which becomes into great potential for the tactical communications systems of the Portuguese Army.

As future work, with regard to the enrichment of the present System, it is proposed to create a mechanism that allows the precedence of calls, that is, firstly, priority levels should be defined among users of the System. When a user of a given priority wants to make a private call with a radio operator, and all gateways designated for private calls are busy, there must be a mechanism that compares the precedence of the user who wishes to make the call. and the lesser user occupying one of these radios. If it is found that the user who wishes to place the call has a higher degree of precedence, then the ongoing call must be terminated so that the radio is free to make new communications and this higher precedence user can make the desired call.

The System is designed to manage and control calls from a CP user. In the future, it will be very useful if a mechanism is developed to allow radio operators to place private calls with a user who is a CP user.

REFERENCES

[1] EID, “PRC-525 COMBAT NET RADIO,” [Online]. Available: http://www.eid.pt/prod/7/prc-525_combat_net_radio/55/Overview. [Accessed on 15 february 2019].

[2] J. Guilherme, “A organização das Transmissões no Exército,” Academia Militar, 2013, p. 2.

[3] C.Santos, “A utilização de novas tecnologias no moderno campo de batalha,” may 2017.

[4] J.Barroso, “O Sistema de Informação e Comunicações Tático (SIC-T) do Exército Português,” em Instituto de Estudos Superiores Militares, Lisboa, 2008.

[5] EID, Rádio Tático HF/VHF/UHF TR-525 - Manual de operação e manutenção, Lisboa, 2014.

[6] B.Goode, “Voice Over Internet Protocol,” em Proceedings of IEEE, 2002, pp. 1495-1517.

[7] Cisco, “Cisco Unified CME Overview,” em CiscoUnified Communications Call Manager Express System Administrator Guide, San Jose, EUA, 2019, pp. 65-76.

[8] A.Shukla, “TCP connection management mechanisms for improving internet server performance,” University of Waterloo, 2005.