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# METHODOLOGY FOR ADAPTING THE RADIO COMMUNICATION SYSTEM OF THE MOBILE COMPONENT OF THE TACTICAL COMMAND AND CONTROL UNIT OF THE NATIONAL GUARD OF UKRAINE TO THE CONDITIONS OF INTENTIONAL INTERFERENCETO PERFORM TASKS OF ENSURING STATE SECURITY

*Adaptation of the radio communication system of the mobile component of the tactical command and control unit of the National Guard of Ukraine to the effects of intentional interference will allow for effective control in modern combat operations. The main problems are equipment obsolescence, high density of radio interference, and dynamic changes in the tactical situation. In order to solve these problems, an adaptation methodology has been developed based on the use of JCATS simulation tools to determine the areas of interference and optimize the location of radio equipment.*

*The methodology involves several stages: identifying areas of radio electronic influence, determining the boundaries of radio interference generators, estimating the error of signal parameters, and adapting the communication system in accordance with the data obtained. Optimized error estimation algorithms are implemented that take into account the quantization effect and provide higher accuracy in estimating signal variance. Additionally, an approach to adaptation through the spatial placement of active radio masking means to reduce the effectiveness of enemy reconnaissance is considered.*

*The simulation modeling tools allow analyzing the effectiveness of various interference protection measures and checking the stability of communication in a variable electronic environment. It is established that the implementation of thedeveloped methodology increases the interference resistance of radio communication by 35 % and intelligence protection - up to 19%, which significantly improves the efficiency of managing mobile units in crisis situations.*

***Keywords:*** *weapons and military equipment, radio communication systems, signals, intentional interference, electronic warfare, power density, adaptation of existing radio communication systems, information and analytical support, automated control system, state security.*

**Statement of the problem.** The main problems of adapting the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine include the following:

1. Outdated and uneven equipment.

– The use of different Soviet and Western-style communication systems makes it difficult to integrate and unify them;

– the lack of a single communication standard leads to compatibility issues.

2. Increased impact of intentional interference on communications and automatedcontrol systems.

– high density of radio interference in the combat zone reduces communication efficiency;

– the enemy is actively using the means of setting up deliberate obstacles.

3. Dynamic changes in the tactical situation.

– Communication systems must be able to quickly adapt to new deployment conditions and possible disruptions;

– The use of mobile communication nodes requires flexible solutions to ensuredata resilience.

One of the possible ways to overcome these problematic issues is to create a methodology for adapting existing radio communication systems operating in conditions of intentional interference to changes in the situation.

**Analysis of research and publications.** Papers [1–2] provide data on information and analytical technologies used by security forces in various levels of management in the performance of tasks to ensure state security, Papers [3–4, 6–7] provide theoretical aspects of protection against intentional interference, protectionof radio networks of the National Guard of Ukraine from enemy radio technical intelligence. Paper [5] presents data on the JCATS simulation modeling system.

**The purpose of the article** is to develop a methodology for adapting the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine to the conditions of intentional interference.

**Summary of the main material.** The National Guard of Ukraine (NGU), as a military formation with law enforcement functions, may participate in repelling armed aggression and eliminating armed conflict by conducting military (combat) operations, performing territorial defense tasks in cooperation with the Armed Forces of Ukraine.

The peculiarities of modern military conflicts lead to the complication of tasks related to countering enemy radio suppression and radio reconnaissance [1–3].

The trend in the development of electronic warfare equipment and the experience of combat operations during the repulsion of the armed aggression of the Russian Federation shows that the main task in organizing a radiocommunication system is to ensure the required indicators of interference resistance in difficult conditions. However, based on the known methods, ensuring the required indicators of interference and intelligence protection is insufficient.

An example of a radio communication system of the mobile component of thetactical command and control link of the National Guard of Ukraine is shown in Figure 1 [4].

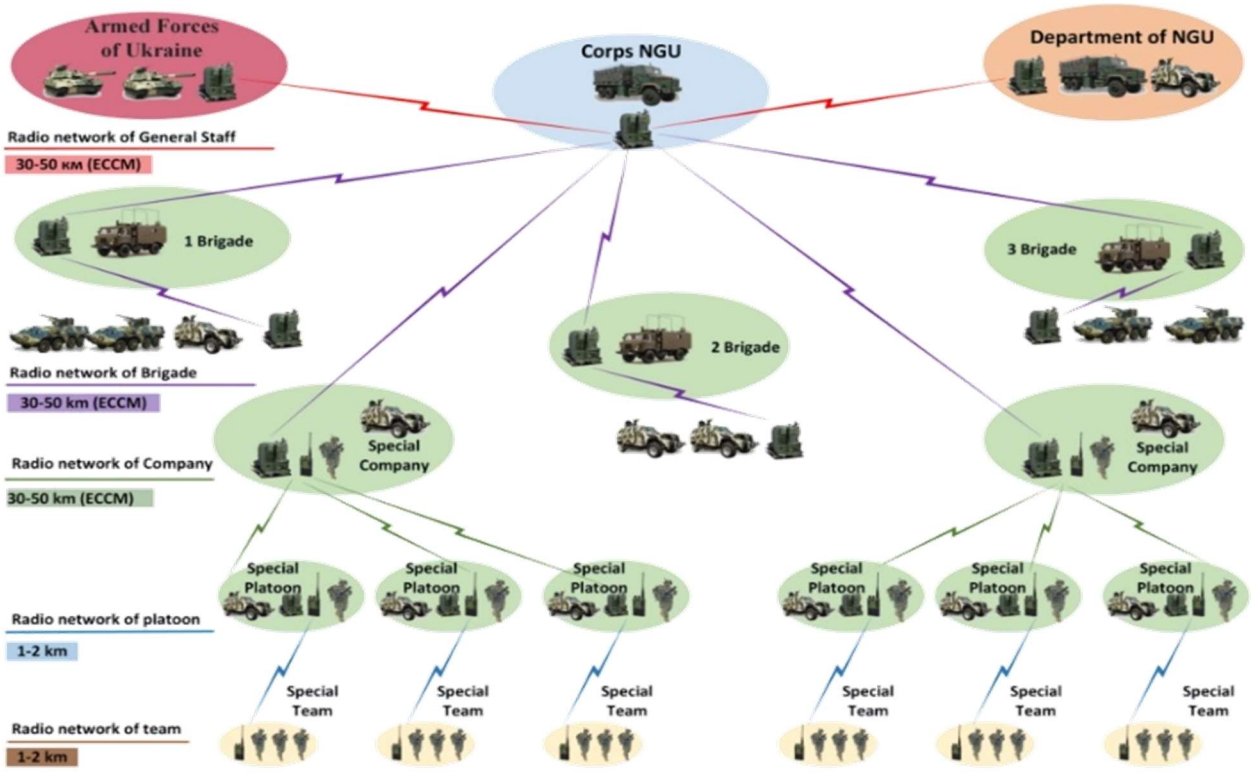


Figure 1 – Radio communication system of the mobile component of the tactical command and control unit of the National Guard of Ukraine

The first stage of the methodology is to identify the areas where the adversary uses radio interference and to estimate the power of this interference. In this paper, we propose to detect the areas of radio interference by the enemy using JCATS simulation modeling.

JCATS is a platform for testing tactical solutions in real time. Its use for modeling radio communications allows [5]:

- identify weaknesses in the communication system and develop methods to eliminate them;
- model the impact of intentional interference and test the effectiveness of anti- interference measures;
- analyze the behavior of the communication system in various combat scenarios.

JCATS allows for iterative testing and the development of new adaptation methods, which can significantly improve the efficiency of radio communications of the mobile component of the tactical command and control link. An example of JCATS simulation modeling is shown in Figure 2.

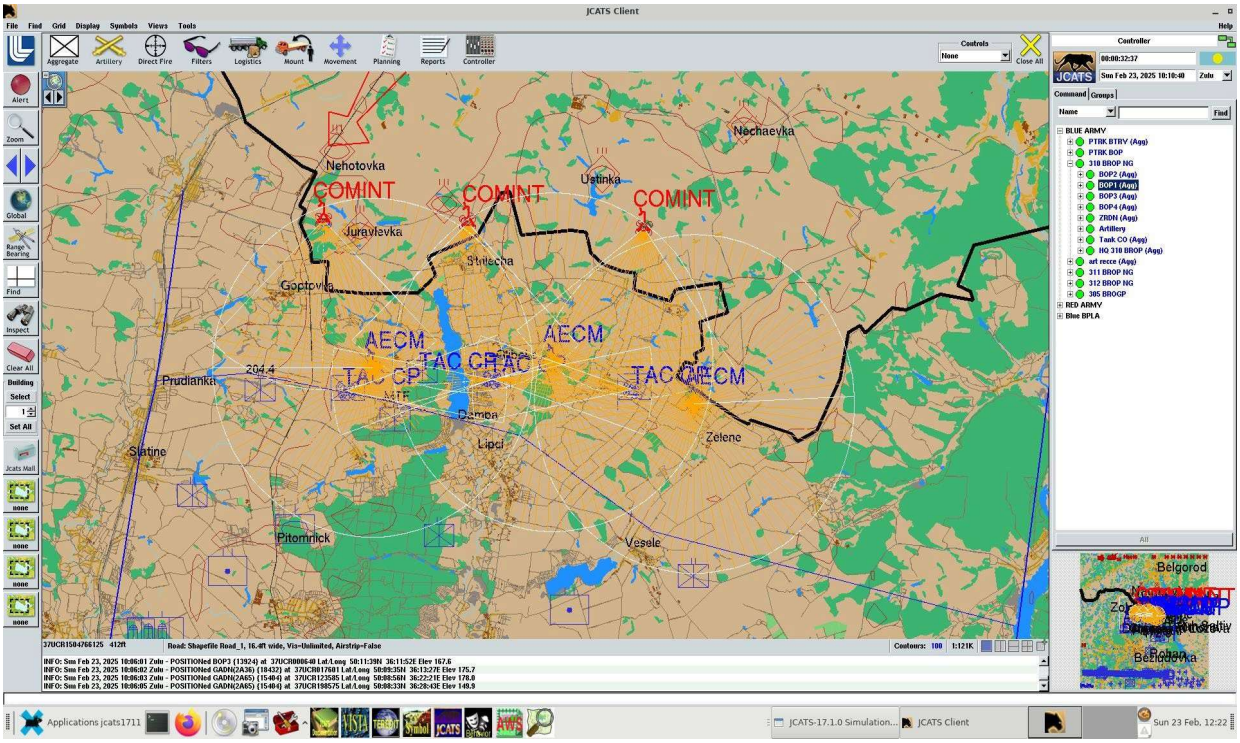


Figure 2 – An example of detecting the enemy's areas of radio jamming using JCATS simulation modeling

At the second stage of the methodology, a method is used to determine the boundaries of the area of possible placement of a radio interference generator to protect mobile radio communications in the UHF/VHF band from listening to an enemy ground reconnaissance radio receiver. The method takes into account the presence of electromagnetic availability zones (EAZ) of mobile radio communication systems and the range of the radio interference generator while meeting the conditions of electromagnetic compatibility (EMC) with the radio means of the communication channel [6].

At the next stage of the methodology, the error in the parameters of the signals of the VHF/UHF and WI-FI radio communication system under the influence of intentional interference during the performance of state security tasks is estimated, which is unlike the known ones [7]:

– takes into account the impact of intentional interference on the estimation of signal variance;

– uses optimized error estimation algorithms that reduce digital processing error;

– offers an adaptive approach to choosing an estimation algorithm depending on the available ones takes into account the effect of signal quantization, which improves the accuracy of variance estimation;

– is of practical importance for improving communication reliability in difficult conditions.

Thus, the novelty of the method lies in its focus on the adaptation of communication systems in conditions of interference, which significantly improvestheir effectiveness in real combat scenarios [7].

At the fourth stage of the methodology, the JCATS simulation modeling tools are used to rationalize the location of active radio masking equipment and radio communication systems on the ground. The simulation modeling tools allow for spatial interference rejection, Figure 2.

To objectively evaluate the effectiveness of interference protection methods, the minimum allowable ratio of the power of the useful signal to the power of intentional interference is used, at which acceptable signal reception quality is guaranteed. If the power of the intentional interference exceeds the power of the useful signal, we proceed to the first stage of the methodology, block 5, and repeat steps 1–4. If the condition in step 5 is met, we proceed to step 6. At step 6, we use the method of adapting the radio communication system of the mobile component of the tactical command and control unit of the National Guard of Ukraine to the

conditions of intentional interference. The method takes into account the availability of communication zones of mobile radio communication systems and the range of the radio interference generator while meeting the EMC conditions with the radio means of the communication channel. The last stage of the methodology is to assess the conditions for achieving stable radio communication of the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine. In the absence of stable radio communication, we proceed to stage 4 and use the JCATS simulation modeling tools to relocate active radio masking equipment and radio communication systems on the ground. If stable radio communication is achieved,a decision is made on the adaptability of the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine to the effects of intentional interference. The scheme of the methodology is shown in Figure 3.

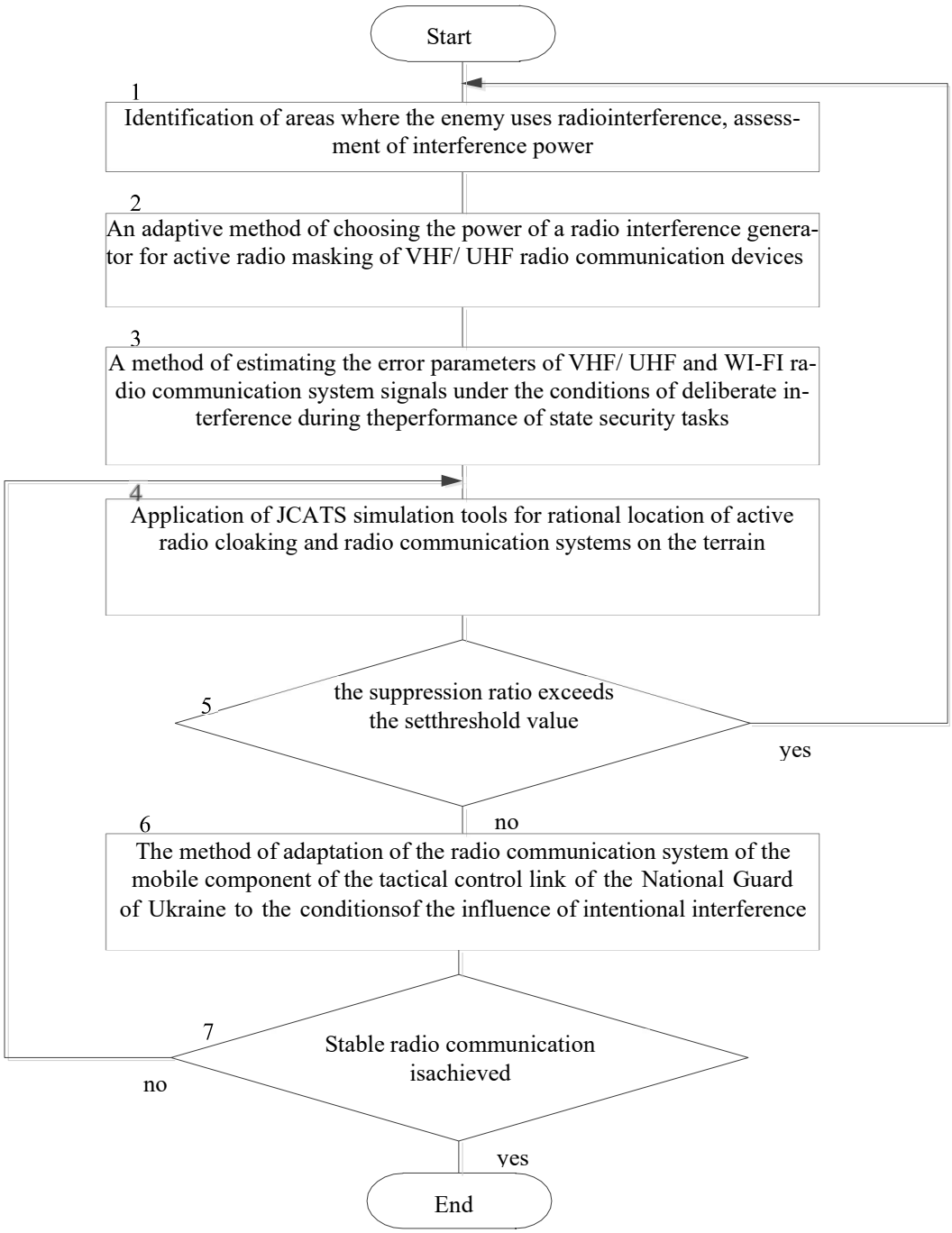


Figure 3 – Schematic of the methodology for adapting the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine to the conditions of intentional interference

## Conclusions

The obtained methodology is based on the rational arrangement and direction of antenna systems of ground-based transmitters and receivers of UHF/VHF and Wi-Fi radio signals in the conditions of intentional interference and active radio masking by the enemy. An approach to the adaptation of the radio communication system of the mobile component of the tactical command and control link of the National Guard of Ukraine is determined, which takes into account the tactical situation and the territorial location of radio network nodes to increase interference protection. The JCATS simulation modeling tools determinedthat the interference resistance of radio communication is improved by 35 %, the intelligence protection of radio communication means increases to 19 %, while the intelligence protection of the radio communication system as a whole is improved by 1.4 times.

The direction of further research is to improve the methodology for adapting control systems for unmanned aerial vehicles to perform tasks to ensure state security.

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# МЕТОДИКА АДАПТАЦІЇ СИСТЕМИ РАДІОЗВ'ЯЗКУ МОБІЛЬНОЇ КОМПОНЕНТИ ТАКТИЧНОЇ ЛАНКИ УПРАВЛІННЯ НАЦІОНАЛЬНОЇ ГВАРДІЇ УКРАЇНИ ДО УМОВ ВПЛИВУ НАВМИСНИХ ЗАВАД ДЛЯ ВИКОНАННЯ ЗАВДАНЬ ІЗ ЗАБЕЗПЕЧЕННЯ ДЕРЖАВНОЇ БЕЗПЕКИ

*Адаптація системи радіозв'язку мобільної компоненти тактичної ланки управління Національної гвардії України до впливу навмисних завад дозволить проводити ефективне управління в умовах сучасних бойових дій. Основними проблемами є застарілість обладнання, висока щільність радіоперешкод та динамічні зміни тактичної обстановки. З метою вирішення цих проблем розроблено методику адаптації, яка базується на використанні засобів імітаційного моделювання JCATS для визначення зон впливу завад та оптимізації розташування радіозасобів.*

*Методика передбачає кілька етапів: виявлення зон радіоелектронного впливу, визначення меж розміщення генераторів радіоперешкод, оцінку похибки параметрів сигналів та адаптацію системи зв'язку відповідно до отриманих даних. Впроваджено оптимізовані алгоритми оцінки похибок, що враховують ефект квантування та забезпечують вищу точність оцінки дисперсії сигналів. Додатково розглянуто підхід до адаптації шляхом просторового розміщення засобів активного радіомаскування для зменшення ефективності розвідки противника.*

*Засоби імітаційного моделювання дозволяють проводити аналіз ефективності різних заходів захисту від завад та перевіряти стійкість зв'язку в умовах змінної радіоелектронної обстановки. Встановлено, що впровадження розробленої методики підвищує завадостійкість радіообміну на 35 %, а розвідзахищеність – до 19 %, що значно покращує ефективність управління мобільними підрозділами в кризових ситуаціях.*

***Ключові слова:*** *озброєння та військова техніка, системи радіозв'язку, сигнали, навмисна завада, радіоелектронна боротьба, щільність потужності, адаптація існуючих систем радіозв'язку, інформаційно-аналітичне забезпечення, автоматизована система управління, державна безпека.*

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