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Methodological Approach to Determining the Priority of Requirements for a Comprehensive Survivability Support System

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Abstract. The modern character of military operations is characterised by an increase in spatial scale, high maneuverability, rapid changes in the operational environment, the need for timely and well-founded decision-making, and the integration of a large number of forces and assets into a unified information and communication space. Against the backdrop of active use of unmanned systems and the transition to multi-domain operations, the survivability of distributed automated organisational control systems for forces and assets becomes a key factor in the effectiveness of military command and control systems. At the same time, the issue of prioritising requirements for a comprehensive survivability support system remains insufficiently addressed in the scientific literature, which complicates the formation of a rational structure for such a system. The aim of the article is to develop one of the possible approaches to determining the priority of requirements for a comprehensive survivability support system, taking into account the uncertainty of combat and electronic warfare environments, as well as the need for adaptive development of distributed automated organisational control systems for forces and assets. A systems approach, the theoretical foundations of graph theory, methods for structuring sets of elements, expert assessment, and the construction of a binary reachability matrix were applied in the study. The procedure includes the formation of an expert group, determination of logical dependencies between requirements, graph construction, and multi-level analysis with the formation of a priority hierarchy. Interdependencies between five key requirements for the comprehensive survivability support system were established: quality, rationality, recoverability, adaptability, and controllability. A priority model was developed, allowing the ranking of requirements by levels of importance. As a result, the following hierarchical structure was determined: first level – quality; second – controllability; third – recoverability; fourth – rationality and adaptability. The proposed approach allows for an objective determination of the key requirements for a comprehensive survivability support system depending on operational conditions and resource constraints. The results can be applied during the design, modernisation, and optimisation of the system structure, as well as in managerial decision-making aimed at enhancing the survivability of distributed automated organisational control systems for forces and assets in modern combat conditions.

Keywords: distributed automated systems, organisational command and control, assets, survivability, integrated survivability support system, requirements, prioritisation.

Introduction

The russian-Ukrainian war provides compelling evidence of the increasing demands placed on automated systems of situational awareness and command and control of assets (C3) [1–4]. This is

primarily driven by the need to establish a unified information space for the effective employment of high-technology weapons and military equipment.

The basis for forming a unified information space is the distributed automated organisational command-and-control systems (DAOC2S) for assets. Alongside their advantages, DAOC2S Assets of the Armed Forces also possess disadvantages, primarily related to their survivability. Ensuring the required level of survivability of DAOC2S Assets is a continuous and purposeful process at all stages of their life cycle and envisages the creation of an Integrated Survivability Support System (ISSS).

To develop a rational structure and composition of the ISSS, it is necessary to establish the requirements for it and determine their prioritisation depending on the state and development of the jamming environment and the decision adopted regarding the deployment of the DAOC2S Assets, which determines the relevance of this study.

Analysis of Recent Research and Publications. Issues of ensuring the survivability of DAOC2S Assets are comprehensively examined in a number of scientific works [5–10]. These works describe the problematic aspects of ensuring survivability of DAOC2S Assets, propose specific measures for resolving these issues, and outline the requirements for the ISSS.

However, under conditions of uncertainty in the combat and jamming environment, there is an urgent need to refine the prioritisation of these requirements. This issue is not comprehensively addressed in the referenced works, which does not allow the determination of a rational variant of the ISSS. Therefore, the purpose of this article is to present one of the possible approaches to determining the prioritisation of requirements imposed on the ISSS.

Results

The functioning of DAOC2S Assets occurs under conditions of uncertainty regarding influencing factors, constant variability of the operational environment, the impossibility of accurately accounting for its reaction to the system's actions and the system's response to external impacts that is, under conditions where such an important systemic property as survivability manifests itself. It is precisely due to survivability that DAOC2S Assets can remain intact under unpredictable, sometimes extreme, conditions, adapt to them, and change their behaviour, structure, or overall systemic functional purpose. Thus, ISSS is an integral part of the CSSS [3, 5-7, 10].

The methodological basis for creating the ISSS consists of the *requirements* imposed on it, namely: quality, rationality, recoverability, adaptability, and controllability (table 1).

The degree to which these requirements are met determines the effectiveness of the CSSS. At the same time, it is taken into account that a rational variant of the CSSS is one in which:

$$EKSSSvar \geq EKSSSreq \quad (1)$$

where *EKSSSreq* is the required effectiveness of the ISSS, selected depending on the conditions and factors of the operational environment and on the decision regarding the deployment of the CSSS of assets;

EKSSSvar is the predicted effectiveness of implementing the rational variant of the ISSS under the assumption of no resource constraints on its implementation.

The predicted effectiveness of the ISSS may be calculated according to the indicators presented in [3], using established methodological approaches [12–14].

During the development of a ISSS for the CSSS of assets, the issue of prioritising the requirements for such a system is of significant practical importance. This prioritisation primarily determines the sequence of implementation of the requirements, i.e. which requirements must be implemented first based on their importance and urgency.

From military practice, such prioritisation may be distributed according to the following levels:
first priority level – implementation sequence *"immediately"*;
second priority level – implementation sequence *"as a first priority";*
third priority level – implementation sequence "*as a second priority*";
fourth priority level – implementation sequence *"subsequently".*

The key indicators that determine the priority of the requirements include:

influence – the degree of direct impact of an implemented requirement on the system's performance of its protective functions and tasks;

urgency – the time required to obtain the effect of implementing the requirement;

value – the degree of impact of the implemented requirement on system effectiveness;

independence – the ability to implement the requirement autonomously, regardless of the implementation of other requirements;

vulnerability – the degree to which the implemented requirement reduces (neutralises) major risks or critical vulnerabilities;

economy – the expected resource expenditure required for implementing the requirement.

Table 1. Core Requirements Imposed on the Integrated Survivability Support System (ISSS)

Requirement Name	Essence of the Requirement	Methods Underpinning the Requirement	Practical Application
Quality	The ability of the ISSS to detect threats, their effects and influence on the components of the DAOC2S Assets; to determine in advance the risks of disruption of functioning and service availability, loss of confidentiality, or distortion of information	Diagnostics, alerting, event logging, user behaviour analysis	Selection of appropriate organisational and technical solutions for active counteraction.
Rationality	The ability of ISSS tools to determine technical approaches regarding the selection of methods and means for solving survivability tasks	Classical preventive protection methods: identification, authorisation, redundancy implementation, access limitation. Special preventive protection methods: reconfiguration, verification, diversification, reconstruction	Support for the continuous functioning and availability of system services under normal operating conditions
Recoverability	The ability of the ISSS to restore its functionality, the operability of components (elements), and the processes ensuring service and resource availability after the impact of threats has been eliminated	Methods of automated restoration of the normal functioning process of the system's backup and auxiliary means; Special methods for restoring the combat readiness of system elements	Transition to advanced technologies for system protection and restoration
Adaptability	The ability of the ISSS to "improve itself" based on experience gained in eliminating threats	Organisational methods (changes in structure; restructuring of subsystems and objects); Modification of procedures and rules (refinement of directives, plans, and control algorithms); Methods for enhancing qualifications and maintaining a high level of personnel competence	Readiness to counter previously unknown threats; Adaptation to new and changed conditions
Controllability	The ability of the ISSS to exert purposeful influence on controlled objects during operation	*Organisational and specialised technical control methods*	Maintaining readiness for system employment and ensuring successful completion of assigned tasks

To solve this task, an appropriate model for the prioritisation of ISSS requirements is constructed using a systemic approach.

The essence of this approach lies in the need to perform certain procedures, namely:

evaluating expert opinions regarding variants of the structure and composition of the ISSS and the feasibility of satisfying the requirements imposed on it;

structuring the requirements imposed on the ISSS by establishing relationships of dependency, equivalence (same-level), and hierarchy among them; building a model for the prioritisation of requirements for the ISSS.

When constructing the model for prioritising ISSS requirements, it is important to clarify the interdependencies among the requirements. This procedure can be implemented through ranking the requirements using a method of structuring a set of elements derived from deductive logic, various observations, brainstorming, or their combinations [11–14].

The method is based on the concepts of graph theory and is used to identify and group elements prior to performing direct calculations of their interdependencies and priorities. The essence of the proposed method lies in structuring a set of interrelated subsystems into a hierarchy obtained using a binary reachability matrix of a directed graph.

The set of vertices of the graph, which is used for the geometric interpretation of relationships among ISSS requirements, is determined using the binary relation “depends on” and is assigned a value of one if the answer is “yes” or zero if the answer is “no.”

The use of a binary reachability matrix allows the set of ISSS requirements to be divided into multiple levels, with each level further subdivided into corresponding subsets. In this case, the prioritisation of levels primarily depends on the number of requirements that are reachable from the respective vertices of the ISSS requirements graph.

The analysis of the graph representing the relationships among ISSS requirements is carried out in the following iterative sequence.

At the first stage, the complete set of ISSS requirements is formed, and the requirements that will constitute the vertices of the corresponding graph are identified.

To establish the dependencies among the requirements, i.e., to build a hierarchy of requirements, each expert indicates the nature of the relationships between them using arrows.

The direction of an arrow is determined according to the following rule: if element A influences element B (A dominates B), the arrow is drawn from A to B

(A → B); if the elements influence each other mutually, a bidirectional arrow is drawn (A ↔ B).

An example of constructing the ISSS requirements graph is shown in Fig 1.

At the second stage, the corresponding *reachability matrix* is constructed. This matrix is a square n-matrix, where *n* is the number of requirements being compared.

The matrix is filled row by row according to the following rule:

if there is a path from vertex “*i*” to vertex “*j*”, the entry is “1”;

if there is no path from vertex “*i*” to vertex “*j*”, the entry is “0”.

An example of a filled reachability matrix is presented in Table 2.

Table 2. Matrix Structure of Relationships Among Requirements Imposed on the ISSS

Requirements	*x*1	*x*2	*x*3	*x*4	*x*5
*x*1	1	1	1	1	1
*x*2	0	1	1	0	0
*x*3	0	1	1	1	0
*x*4	0	1	1	1	0
*x*5	0	1	1	1	1

At the *third stage*, the mathematical processing of the reachability matrix is carried out, and the final hierarchy of requirements imposed on the ISSS is constructed.

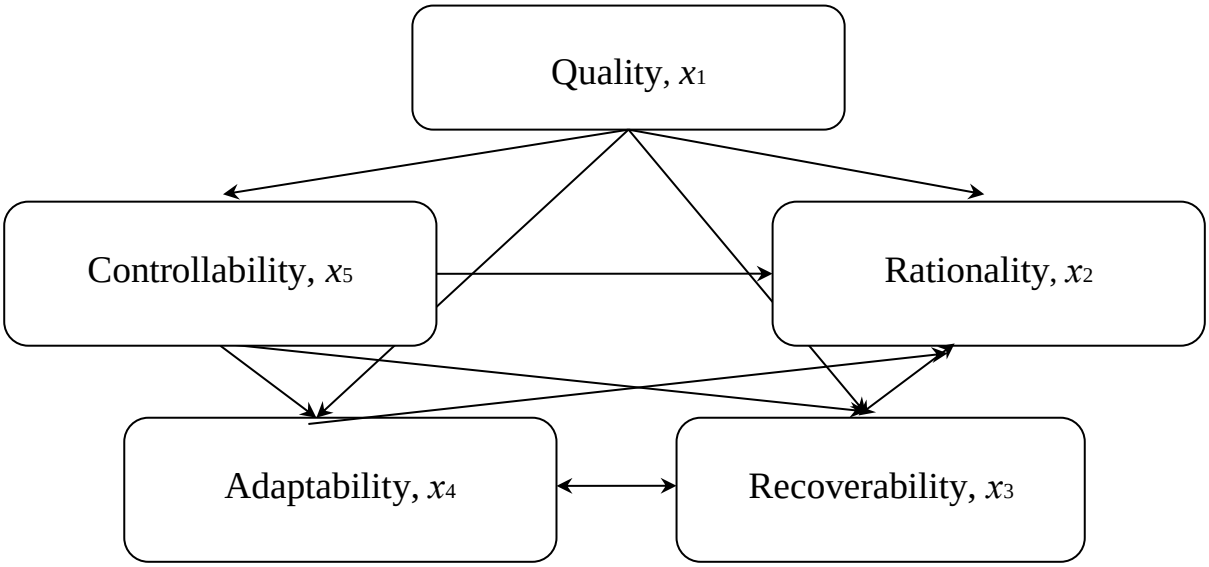


Fig 1. Graph of Relationships Among Requirements Imposed on the ISSS

For the mathematical processing, a calculation table of size *n*x*m* is formed, where *n* is the number of rows corresponding to the number of requirements, and *m* is the number of columns.

The first column contains the name of the requirement, The second column contains the subset of all requirements *H*(*xi*), that are reachable from the *x*-th requirement. In other words, the first column lists all requirement numbers that have a "1" in the matrix row corresponding to the *x*- th requirement.

The second column also represents the subset of requirements *H*(*xi*), from which the requirement *xi*, is reachable; i.e., for this number, all indices with a "1" are listed by columns.

The third column contains the intersection of the subsets *H*(*xi*) and *B*(*xi*), i.e., $H(xi) \cap B(xi)$.

According to these rules, the first level of the ISSS requirements hierarchy includes those requirements for which the following equality holds:

$$H(xi) = H(xi) \cap B(xi). \quad (2)$$

Next, the requirements of the first hierarchy level are removed from the reachability matrix, and the procedure is repeated.

An example of a filled first calculation table for the considered case of ISSS requirements is presented in Table 3.

Requirement *x*1, satisfies equality (2), and therefore it belongs to the *first level* of the hierarchy.

Next, the procedure is repeated excluding the first row and the first column of the matrix structure of relationships among the requirements imposed on the ISSS, as presented in Table 1.

The next calculation table, Table 4, is then formed.

In a similar manner, the remaining calculation tables are formed, which ultimately allow the prioritisation of requirements imposed on the ISSS to be determined.

For our case, the hierarchical structure of ISSS requirements prioritisation is as follows:

the first priority level (implementation sequence "immediately") comprises the requirements related to quality, x1;

the second priority level (implementation sequence "as a first priority") comprises the requirements related to controllability, x5;

the third priority level (implementation sequence "subsequently") comprises the requirements related to recoverability, x3;

the fourth priority level (implementation sequence “subsequently”) comprises the requirements related to rationality, x2 and adaptability, x4.

Table 3. Calculation Table

Requirement, *xi*	Subset of requirements reachable from *x*-th requirement, *H*(*xi*)	Subset of requirements *H*(*xi*), from which is reachable, *xi*, *B*(*xi*)	Intersection of subsets *H*(*xi*) and *B*(*xi*), *H*(*xi*) ∩ *B*(*xi*)
*x*1	1, 2, 3, 4, 5	1	1
*x*2	2, 3	1, 2, 3, 4, 5	2, 3
*x*3	2, 3, 4	1, 2, 3, 4, 5	2, 3, 4
*x*4	2, 3, 4	1, 3, 4, 5	3, 4
*x*5	2, 3, 4, 5	1, 5	5

Table 4. Calculation Table

Requirement, *xi*	**Subset of requirements reachable from *x*-th requirement, *H*(*xi*)**	**Subset of requirements *H*(*xi*), from which is reachable, *xi*, *B*(*xi*)**	**Intersection of subsets *H*(*xi*) and *B*(*xi*), *H*(*xi*) ∩ *B*(*xi*)**
*x*2	2, 3	2, 3, 4, 5	2, 3
*x*3	2, 3, 4	2, 3, 4, 5	2, 3, 4
*x*4	2, 3, 4	3, 4, 5	3, 4
*x*5	2, 3, 4, 5	5	5

Conclusion

The survivability of distributed automated organisational control systems (ISSS) of the armed forces can be ensured through the implementation of specific methods, techniques, and tools that allow the system to function under conditions of uncertainty and unforeseen situations. Further development of ISSS is impossible without the creation of an appropriate Comprehensive Survivability Support System (CSSS).

For the formation of a rational CSSS variant, a crucial task is the prioritisation of requirements for this system. In this study, a methodological approach was developed based on graph theory concepts, which allows requirements to be identified and grouped, and their interdependencies and prioritisation to be directly calculated.

In the future, it is advisable to organise research aimed at determining a rational variant of the CSSS structure and composition.

Conflict of Interest

The author of the article is a member of the editorial board. To avoid a conflict of interest, the editorial process was conducted by Oleh Semenenko.

References

1. Zaluzhnyi, V. F. (2025). Military forces and weapons management system: Development trends in modern armed conflict. *Electronic Modelling*, *47*(2), 67–80.
2. Zaluzhnyi, V. F., Shaptala, S. O., Koval, V. V., Nazarov, V. M., Hryshchuk, R. V., Baranov, S. M., & Semenenko, O. M. (2023). *Principles of development of robotic systems in the Armed Forces of Ukraine* (O. M. Semenenko, Ed.). Kyiv: 7BC.
3. Zaluzhnyi, V. F. (2025). Performance (quality) indicators of the comprehensive survivability support system for distributed automated organisational control systems of assets. *Data Registration, Storage and Processing, 27*(1), 42–50.

4. Horbulin, V. P., & Mosov, S. P. (2024). Drone swarms – The culmination of drone warfare. *Bulletin of the National Academy of Sciences of Ukraine, (3)*, 3–11. https://doi.org/10.15407/visn2024.03.003
5. Dodonov, O. H., Horbachik, O. S., & Kuznetsova, M. H. (2007). Survivability of information-analytical systems: Terminology, analysis and assessment models. *Data Registration, Storage and Processing, 9*(3), 61–72.
6. Dodonov, O. H., Kuznetsova, M. H., & Horbachik, O. S. (2009). *Survivability of complex systems: Analysis and modelling* (Textbook in 2 parts). Kyiv: NTUU "KPI".
7. Dodonov, O. H., Horbachik, O. S., & Kuznetsova, M. H. (2010). System studies of survivability and safety of complex technical systems. *Data Registration, Storage and Processing, 12*(2), 202–208.
8. Zahorka, O. M., Pavlikovskyi, A. K., Koretskyi, A. A., Kyrychenko, S. O., & Zahorka, I. O. (2020). *Theoretical foundations of force group (troop) management in modern armed conflict* (I. S. Rusnak, Ed.). Kyiv: NUUOU.
9. Permyakov, O. Yu., Korolyuk, N. O., & Pharaoh, S. I. (2024). *Intelligent military information systems*. Kyiv: NUUOU.
10. Lande, D. V. (2012). Methods for increasing the survivability of the information component of corporate information-analytical decision support systems. *Data Registration, Storage and Processing, 14*(2), 48–58.
11. Behma, V. M., Zahorka, O. M., Kosevtsov, V. O., & Shemaiev, V. M. (2005). *Strategic management of military-technical cooperation in the interests of ensuring Ukraine's military security* (I. S. Rusnak, Ed.). Kyiv: IPNB, NAOU.
12. Zahorka, O. M., Mosov, S. P., Sbitnev, A. I., et al. (2005). *Elements of research of complex military systems*. Kyiv: NAOU.
13. Radetskyi, V. H., Rusnak, I. S., Zahorka, O. M., et al. (2007). *Methodological foundations for justifying rational forms and methods of using force groups* (S. O. Kyrychenko, Ed.). Kyiv: NAOU.
14. Saaty, T. (1993). *Decision making. The analytic hierarchy process* (R. G. Vachnadze, Trans.). Moscow: Radio i Sviaz.

Методичний підхід визначення пріоритетності вимог до комплексної системи забезпечення живучості розподілених автоматизованих систем організаційного управління силами та засобами

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Анотація. Сучасний характер бойових дій характеризується зростанням їх просторових масштабів, високою маневреністю, різкими змінами обстановки, потребою в оперативному ухваленні обґрунтованих рішень та інтеграції великої кількості сил і засобів у єдиному інформаційно-комунікаційному просторі. На тлі активного застосування безпілотних систем та переходу до мультидоменних операцій ключовим фактором ефективності систем управління військами та зброєю стає забезпечення живучості розподілених автоматизованих систем організаційного управління силами та засобами. Водночас у наукових джерелах недостатньо розкритим залишається питання пріоритетності вимог до комплексної системи

забезпечення живучості, що ускладнює формування раціональної структури цієї системи. Мета статті – розробити один із можливих підходів до визначення пріоритетності вимог, що висуваються до комплексної системи забезпечення живучості, з урахуванням невизначеності бойової та завадової обстановки та необхідності адаптивного розвитку розподілених автоматизованих систем організаційного управління силами та засобами. У роботі застосовано системний підхід, теоретичні засади теорії графів, методи структурування множини елементів, експертного оцінювання та побудови бінарної матриці досяжності. Процедура включає формування експертної групи, визначення логічних залежностей між вимогами, побудову графу та багаторівневий аналіз із формуванням ієрархії пріоритетів. Встановлено взаємозалежності між п’ятьма основними вимогами до комплексної системи забезпечення живучості: якістю, раціональністю, відновлюваністю, адаптивністю та керованістю. Побудовано модель пріоритетності, яка дозволяє ранжувати вимоги за рівнями важливості. У результаті визначено таку ієрархічну структуру: перший рівень – якість; другий – керованість; третій – відновлюваність; четвертий – раціональність та адаптивність. Запропонований підхід дозволяє об’єктивно визначати ключові вимоги до комплексної системи забезпечення живучості залежно від умов її функціонування та ресурсних обмежень. Результати можуть бути використані під час проєктування, модернізації та оптимізації структури системи, а також при ухваленні управлінських рішень щодо підвищення живучості розподілених автоматизованих систем організаційного управління силами та засобами у сучасних бойових умовах.

Ключові слова: розподілені автоматизовані системи, організаційне управління, сили та засоби, живучість, комплексна система забезпечення живучості, вимоги, пріоритетність.