| Artículo de reflexión | Reflection Article | Artigo de reflexão |

Geospatial collective intelligence approach in the appreciation phase of military planning

Fecha de recibido: 15 de febrero 2023	Fecha de aprobado: 28 de abril 2023
Reception date: February 15, 2023	Approval date: April 28, 2023
Data de recebimento: 15 de Fevereiro de 2023	Data de aprovação: 28 de abril de 2023

Alex Fernando Jiménez Vélez
https://orcid.org/0000-0003-4667-0838
ajimenez@fae.mil.ec

Ph.D. in Engineering and Projects
Professor and researcher – University of Armed Forces ESPE, Ecuador
Researcher's role: theoretical and writing
CELSO Research Group

Ph.D. en Ingeniería y Proyectos
Docente e investigador – Universidad de Fuerzas Armada ESPE, Ecuador
Rol del investigador: teórico y escritura
Grupo de Investigació CELSO

Doutoramento em Engenharia e Projectos
Docente e investigador – Universidade das Forças Armadas ESPE, Equador
Papel do investigador: teórico e escritor
Grupo de investigação CELSO

Escuela de Postgrados **Fuerza Aérea Colombiana**

Cómo citar este artículo: Jiménez Vélez, A. F. (2023). Geospatial collective intelligence approach in the appreciation phase of military planning. *Ciencia y Poder Aéreo*, *18*(2), 67-74. https://doi.org/10.18667/cienciaypoderaereo.772

Geospatial collective intelligence approach in the appreciation phase of military planning

Abstract: Military planning is an important process that allows to determine the best tactic and the most efficient mean to use military power, allowing command staff to make accurate and prompt decisions. For this purpose, it is essential to have a deep knowledge of military science and operational factors such as geographic space, force, and time, which results in greater probabilities of success in the execution of military operations. This research article intends to propose a new approach in the appreciation phase of military planning based on a research project called *Collective Intelligence Geospatial Planning Model*, which works through an automation of the Real Time Spatial Delphi method from a web-based tool called Geospatial System of Collective Intelligence (SIGIC, acronyms in Spanish). Such automation obtains a geo-consensus that allows us to conclude if it would be relevant or adequate to provide or give support to the commander in complex geographical scenarios. Current and prospective geospatial patterns can be established through geo-consensus, which is mainly focused on the planning, organization, and use of territorial resources.

Keywords: Collective intelligence; military planning; Spatial Delphi method; Spatial Decision Support Systems.

Enfoque geoespacial de inteligencia colectiva en la fase de apreciación de la planificación militar

Resumen: La planificación militar es un proceso esencial por el cual se puede llegar a determinar la mejor idea de maniobra y la forma más eficiente de empleo del poder militar, lo que permite al comandante tomar decisiones acertadas y oportunas. Para ello es fundamental un conocimiento profundo de la ciencia militar, así como de factores operacionales como espacio geográfico, fuerza y tiempo que permitan tener mayores probabilidades de éxito en la ejecución de las operaciones militares. Este artículo de investigación pretende plantear un nuevo enfoque en la fase de apreciación de planificación militar basado en un proyecto de investigación denominado *Modelo de Planificación Geoespacial de Inteligencia Colectiva*, mismo que tiene como método principal al método Delphi Espacial en tiempo real, automatizado a través de una herramienta web denominada Sistema Geoespacial de Inteligencia Colectiva (SIGIC), mediante la cual se obtiene un geoconsenso que nos permite concluir que sería pertinente o adecuado para poder brindar o dar soporte al comandante en escenarios geográficos complejos; así como también establecer patrones geoespaciales actuales y prospectivos enfocados principalmente a la planeación, organización y empleo de recursos territoriales.

Palabras clave: inteligencia colectiva; método Delphi Espacial; planificación militar; Sistemas de Soporte a la Decisión Espaciales.

Enfoque de Inteligência Colectiva Geoespacial na fase de apreciação do planeamento militar

Resumo: O planejamento militar é um processo essencial pelo qual a melhor idéia de manobra e o uso mais eficiente do poder militar podem ser determinados, permitindo ao comandante tomar decisões precisas e oportunas; para isso, é essencial um conhecimento profundo da ciência militar e de fatores operacionais como espaço geográfico, força e tempo, permitindo uma maior probabilidade de sucesso na execução de operações militares. Este artigo estimulante tem como objetivo propor uma nova abordagem para a fase de avaliação do planejamento militar com base em um projeto de pesquisa chamado Modelo de Planejamento Geo-espacial de Inteligência Coletiva, no qual através da automatização do método Delphi Espacial em tempo real em uma ferramenta web chamada Sistema Geoespacial de Inteligência Coletiva (SIGIC) obtendo um geoconsenso que nos permite concluir que seria relevante ou adequado fornecer ou apoiar o comandante em cenários geográficos complexos, através do qual podem ser estabelecidos padrões geoespaciais atuais e prospectivos, principalmente focados no planejamento, organização e utilização de recursos territoriais.

Palavras-chave: Inteligência coletiva; método Delphi Espacial; planeamento militar; Sistemas de Apoio à Decisão Espacial.

Introduction

The evaluation and management of human, material, financial, technological, and natural resources are essential in decision-making at all levels of war planning. Any military organization and its staff, especially High Command, requires a strategic system that helps him or her to conceive and plan and direct his or her activities, identifying in each case the best ideas for maneuver.

Geospatial entities allow to incorporate locations and characteristics of both natural and social aspects, visible and invisible elements of geographic space on a geographic information system, as well as the relationships formed between them. Their study requires a systematic and systemic complex treatment of the "inseparable set of systems of objects, and systems of actions, which enables going from the past to the future, through the consideration of the present" (Santos, 2006, p. 60), thus making the elaboration of current and prospective studies and models within a given context of force, time, and space possible, even constituting under this approach a recent field of research called geo-prospective (Emsellem *et al*., 2012), (Houet & Gourmelon, 2014), (Voiron, 2012). Given the complexity of these scenarios, to address the decision-making support process, command staff must resort to the Integral Work of the General Staff (TIEM, acronyms in Spanish), provided by the staff members who, through shared epistemological, conceptual, and methodological frameworks, contribute to the development of feasible alternatives, thanks to the inter-subjective tendencies provided by their knowledge, analysis, and social responsibility.

Geospatial collective intelligence approach

The objective of this approach focuses on a complementary methodology for the TIEM and the military planning process, which for the first time converges collective intelligence, complexity theory, decision theory, Spatial Decision Support Systems (SDSS), Group Decision Support Systems (GDSS), and geo-prospective. To test this new approach, a geospatial web-GDSS application was designed and built combining such tools. A software function designed from the spatial version of the Delphi method (Di Zio & Pacinelli, 2011) was added to the real time Delphi method (Gnatzy *et al*., 2011), (Hsieh *et al*., 2011), and the Vector Consensus model (Monguet *et al*., 2010).

This application will allow to present High Command a survey whose purpose is to identify the factors or aspects to be evaluated in a certain geographical space, both at present and in the possible future, such as: the location of a deployment point, a communication antenna, military checkpoints, among others.

Each subject and military expert who participates in this space survey anonymously provides their opinion regarding the place they consider appropriate to install a particular infrastructure or service, placing a point on the map and complementing it with a brief insert message explaining the reason. Additionally, the platform contains information of interest such as: documents, videos, photographs, etc., which would serve as assistance to the survey process and, likewise, each subject can share the information available to the rest of the group if they desire.

Moreover, each expert can use the means they consider convenient according to their criteria: knowledge, training, and possibilities to provide the requested location, thus constituting an exercise of collective intelligence, understood as the "capacity of human collectives to participate in intellectual cooperation to create, innovate, and invent" (Levy, 1997, p. 254).

From the points obtained in the consensus, the function will compose a geospatial pattern constituted by an arrangement of geo-atoms (Goodchild *et al*., 2007), which will include all the qualitative and quantitative properties found in them, according to the different levels of geospatial information used in the system, whether vector, raster, or matrix.

Based on this initial pattern, a classification of the study area will be made from an artificial neural networks algorithm of multilayer type, since they have presented encouraging results in numerous geographical problems, and some advantages over other methods traditionally used for data classification (Painho *et al*., 2005). The result provided by the Commander will be composed of a thematic map showing for each statement of the survey the sites that present similarities with respect to the corresponding initial pattern, weighting the locations in three ranges of similarity (high, medium, and low). Additionally, the location of the initial pattern will be highlighted (the place where the consensus of the group of experts was obtained), and a text will be provided composed of the arguments of the group supporting the positions.

Methodology and application framework

A geospatial collective intelligence model for military planning was used in the different stages of a territorial decision-making process through a geospatial system of collective intelligence (from Spanish: Sistema Geoespacial de Inteligencia Colectiva — SIGIC) (Castillo *et al*., 2015). These stages are embedded within the real-time spatial Delphi method and can be adjusted to any type of military problem, seeking to determine suitable places to locate goods, services, and/or events related to territorial aspects areas (refer to Figure 1).

Stage 1: In this phase called **Approach**, the military planning problem to be solved is defined in a general way, this must be derived from a need that afflicts those involved. This stage allows us to know the problem in a specific geographical context. In the case of the exercise carried out in Antarctica, this technical analysis is performed using a multidisciplinary group composed of researchers, officers of the Army, Navy and Air Force of Ecuador who have participated in the Ecuadorian campaigns to Antarctica (some of which are based in other countries of the world).

Stage 2: In this phase called **Analysis**, once the problem to be solved has been determined, the existing multisectoral information on the problem is analyzed, determining the main causes that generate the military problem.

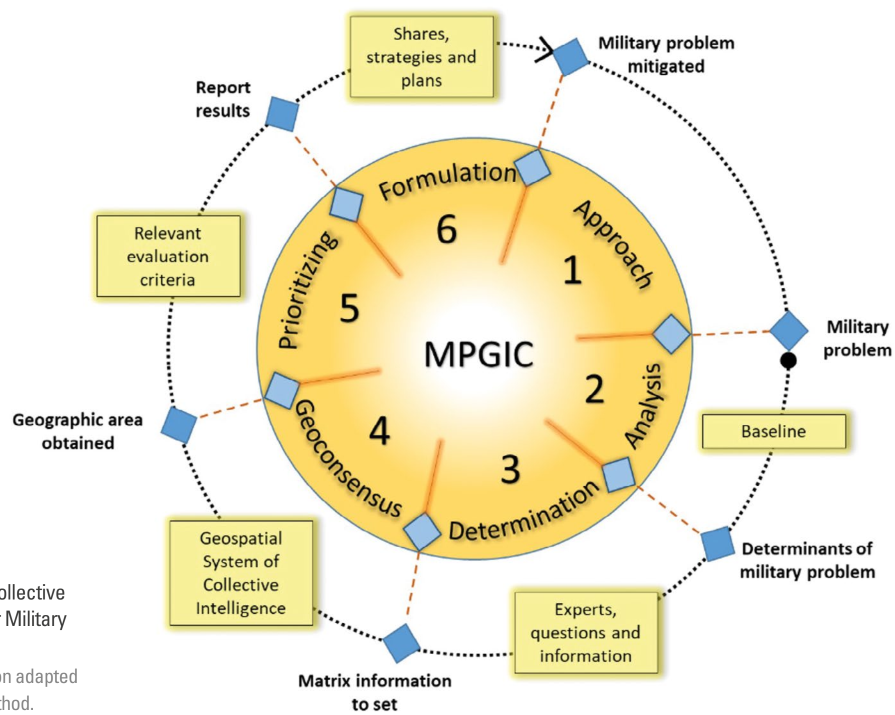

Figure 1. Geospatial Collective Intelligence Model for Military Planning (GCIMHP)

Source: Own elaboration adapted from Spatial Delphi Method.

Stage 3: This phase called **Determination** consists in determining the group of experts, questions, and suitable information necessary to consider for the solution of the problem. For this purpose, all this information must be filled in a configuration matrix, which will allow through the application called Geospatial System of Collective Intelligence (SIGIC, acronyms in Spanish) to start with the interaction of the geo-consensus phase. For the exercise, the question determined the participation of a group of seventeen people composed of researchers, officers of the Army, Navy and Air Force of Ecuador who have participated in the Ecuadorian campaigns to Antarctica and its geographical context to be evaluated. Within the panel of experts, questions asked and relevant information are detailed in Table 1. With this information (and other aspects), a configuration matrix was structured to enter all these parameters in the application developed under this approach.

Table 1.
Description of the information required for the application architecture of SIGIC

Item	Description
Question	What is the site of scientific interest around the Pedro Vicente Maldonado Station, where visitor access should be restricted?
Panel of experts	Seventeen analysts (ten Antarctic researchers, seven officers from different Ecuadorian armed forces).
Geographic information	Georeferenced orthophoto scientific station "Pedro Vicente Maldonado". Station physical infrastructure layer.
Non-georeferenced information	Antarctic campaign information.

Source: Own elaboration.

Stage 4: In this phase called **Geoconsensus**, based on the configuration matrix and generated in the previous stage, we proceed to configure: the questions to be asked, the experts that will intervene in the solution of the problem, and all the base intersectorial information (geo-referenced and non-georeferenced) provided for consultation of the experts, in each of the panels for the effect that we have in the SIGIC.

Once all these parameters have been configured, we proceed to carry out the following activities in the following order:

1. An invitation is sent by e-mail to the group of experts, who upon acceptance, may participate under anonymity by analyzing the intersectorial data provided in the system itself for the purpose.
2. A (spatial) survey is presented, through which the experts are asked to identify the location they consider ideal for the goods, services or events in a given geographic space. The purpose of this is projecting those scenarios with the sought-after purposes.
3. Each expert responds anonymously to the survey, giving his or her opinion by positioning a point on the map and complementing it with a brief text message supporting the response.
4. In this way, each participant examines in real time the prevailing geo-consensus in an area of the map (in which there is at least 50 % of the opinions of all participants), and can also observe whether his or her opinion is positioned within or outside the consensus, as well as the textual arguments of the other participants. However, he or she cannot know which expert has given his or her opinion in each case, nor the exact location of the opinions, thus encouraging controlled feedback and encouraging the search for geo-consensus.

The geo-consensus area will therefore indicate a model with the optimal locations for the required goods, services or events, from a purely interdisciplinary approach, and together with the arguments provided, the needs, strengths and weaknesses of the corresponding territory will be exhibited.

It should be noted that this phase is carried out through the Internet at the time and place that each expert panelist has available for this purpose.

Stage 5: In this phase called **Prioritization**, with the areas and arguments resulting from the geo-consensus, all the arguments provided by the experts are evaluated, prioritizing those that are common or of greater relevance within the spatial consensus

Escuela de Postgrados Fuerza Aérea Colombiana

or geo-consensus, thus determining the strengths or weaknesses of that location.

Stage 6: In this phase called **Formulation**, with the results obtained through geo-consensus, and after determining the strengths and territorial weaknesses of each area, organization, and use of resources in the territory, a decision was reached. The actions, strategies, and plans to locate goods, services, or events to mitigate the proposed military problem contributed to the decision-making process.

Empirical evaluation

As part of the evaluation of this approach we proceeded to conduct a first study the previous year at the Ecuadorian Antarctic Institute, an entity attached to the Ministry of National Defense of this country under the framework of the XX Antarctic Campaign 2015-2016, where a multidisciplinary group composed of researchers, officers of the Army, Navy and Air Force of Ecuador who have participated in the Ecuadorian campaigns to Antarctica (of which some are based in other countries of the world), collaborated in an exercise to contribute their knowledge and experience in order to locate, through anonymity and the convergence of their opinions, some areas of priority interest for the planning of activities at the Pedro Vicente Maldonado Station.

The Fig. 4 shows the history of the geo-consensus, which once the exercise was completed was determined in a diameter d=66.82 m with an area of a= 3507.12 m

In the main arguments that were obtained from the criteria of the experts, they determined the geo-consensus was oriented towards precautionary and restricting the nesting area of species typical of the Antarctic ecosystem.

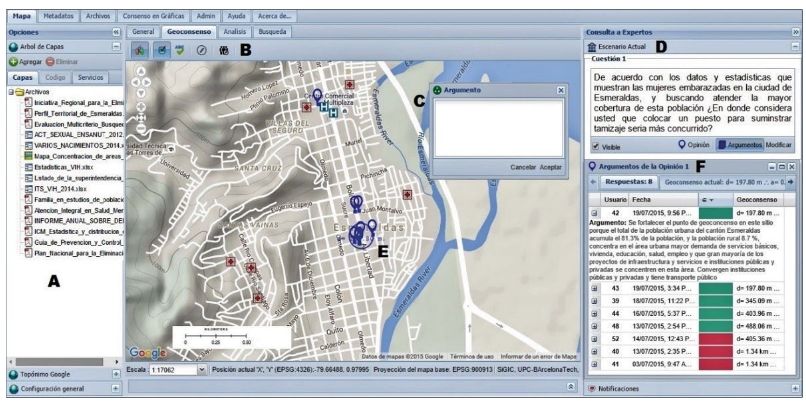

Figure 2. SIGIC User Interface. Where we can observe the elements configured to interact under this approach: A. Information panel; B. Geo-consensus tools; C. Expert Opinion; D. Questions Panel; E. Obtaining the geo-consensus F. List of arguments

Source: Own elaboration.

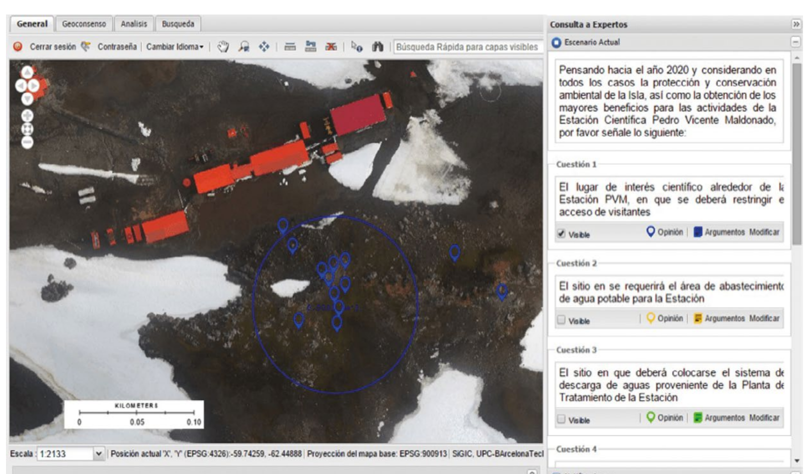

Figure 3. Screenshot of the case study in the planning of logistics operations at the Pedro Vicente Maldonado Scientific Station – Antarctica

Source: Own elaboration.

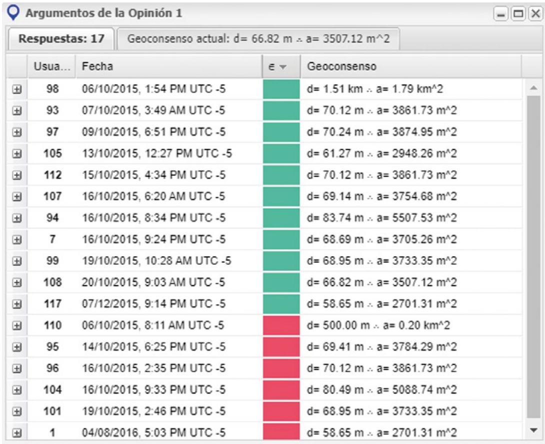

Figure 4. Screenshot of the geo-consensus record

Source: Own elaboration.

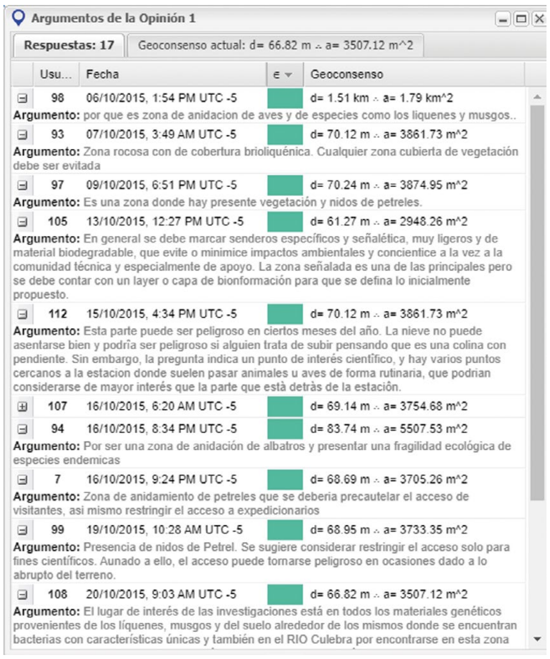

Figure 5. Screenshot of the main arguments

Source: Own elaboration.

Conclusion

The results obtained from this first exercise allow us to determine that this new approach could be applied, with the appropriate adaptation, in the planning of air operations by incorporating in the TIEM a collective online feedback; also by taking into consideration the General Staff as a collective subject, allowing to provide the Commander a multiple and interdisciplinary panorama of alternatives that facilitate his or her decision making, among which the strengths and vulnerabilities of geographical points can be mapped in order to plan, organize and execute military operations tending to avoid or accelerate their occurrence with respect to the desired future, constituting a tool of territorial strategic intelligence available to the command, at different levels of war planning.

References

Castillo Rosas, J. D., Jiménez Vélez, Á. F., Díez Rodríguez, J. J., Monguet Fierro, J. M. & Núñez Andrés, M. A. (2015). Geospatial System of Collective Intelligence: A technological application for the interdisciplinary study of the geographical space complexity. *Collective Intelligence Conference*, Michigan, EEUU https://sites.lsa.umich.edu/collectiveintelligence/wp-content/uploads/sites/176/2015/06/Rosas-CI-2015-Abstract.pdf

Di Zio, S. & Pacinelli, A. (2011). Opinion convergence in location: A spatial version of the Delphi method. *Technological Forecasting and Social Change, 78*(9), 1565-1578. https://doi.org/10.1016/j.techfore.2010.09.010

Emsellem, K., Liziard, S. & Scarella, F. (2012). La géoprospective: l'émergence d'un nouveau champ de recherche. *Espace géographique, 41*(2), 154-168. https://doi.org/10.3917/eg.412.0154

Gnatzy, T., Warth, J., von der Gracht, H. & Darkow, I. L. (2011). Validating an innovative real-time Delphi approach - A methodological comparison between real-time and conventional Delphi studies. *Technological Forecasting and Social Change, 78*(9), 1681-1694. https://doi.org/10.1016/j.techfore.2011.04.006

Goodchild, M. F., Yuan, M. & Cova, T. J. (2007). Towards a general theory of geographic representation in GIS. *International Journal of Geographical Information Science*, *21*(3), 239-260. https://doi.org/10.1080/13658810600965271

Hsieh, C. H., Tzeng, F. M., Wu, C. G., Kao, J. S. & Lai, Y. Y. (2011). The comparison of online Delphi and real-time Delphi. *Proceedings of PICMET '11: Technology Management in the Energy Smart World (PICMET)*, (pp. 1-3). https://ieeexplore.ieee.org/abstract/document/6017652

Escuela de Postgrados **Fuerza Aérea Colombiana**

Houet, T. & Gourmelon, F. (2014). La géoprospective – Apport de la dimension spatiale aux démarches prospectives. *Cybergeo: European Journal of Geography*. [En ligne], Systèmes, Modélisation, Géostatistiques, document 667, mis en ligne le 08 février 2014, consulté le 29 mai 2023. URL : http://journals.openedition.org/cybergeo/26194 ; DOI : https://doi.org/10.4000/cybergeo.26194

Monguet, J., Ferruzca, M., Gutiérrez, A., Alatriste, Y., Martínez, C., Cordoba, C., Fernández, J., Sanguino, T. & Aguilà, J. (2010). Vector Consensus: Decision Making for Collaborative Innovation Communities [conference]. *Enterprise Information Systems: International Conference, CENTERIS 2010*, Viana do Castelo, Portugal. https://doi.org/10.1007/978-3-642-16419-4_22

Lévy, P. (1997). Education and training: New technologies and collective intelligence. *Prospects, 27*(2), 248-263. https://doi.org/10.1007/BF02737169

Painho, M., Vasilakos, A., Bacao, F. & Pedrycz, W. (2005). Exploring spatial data through computational intelligence: a joint perspective. *Soft Computing*, 9, 326-331. https://doi.org/10.1007/s00500-004-0411-6

Santos, M. (2006). The nature of space: technique and time, reason and emotion. Edusp, Sao Paulo, 4. https://ebin.pub/the-nature-of-space-1478013486-9781478013488.html.

Voiron-Canicio, C. (2012). L'anticipation du changement en prospective et des changements spatiaux en géoprospective. *Espace géographique, 41*(2), 99-110. https://doi.org/10.3917/eg.412.0099