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Proposal of optimization models formovements of Brazilian Army military personnel

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RESUMO: A movimentação dos militares do Exército Brasileiro (EB) entre as diversas Organizações Militares (OM), essas agrupadas nas chamadas guarnições em diversas cidades, é uma atividade realizada anualmente pela Diretoria de Controle de Efetivos e Movimentações (DCEM), que tem como objetivo atender, da melhor maneira possível, às necessidades da Força e aos interesses dos militares. Para otimizar as movimentações dos militares, este artigo apresenta o desenvolvimento de um modelo matemático baseado em um problema de alocação de recursos e compara os resultados obtidos com aqueles apresentados pelo Sistema de Apoio às Decisões para Movimentações (SADMov), atualmente em uso, que se baseia em um algoritmo construtivo. Realizaram-se experimentos computacionais para uma amostra de 277 tenentes da arma de Infantaria, 374 guarnições e 912 organizações militares. Os resultados das otimizações indicaram um atendimento positivo de 121% para os militares e de 34% para as OM.

PALAVRAS-CHAVE: Movimentação de pessoal. Problema de alocação. Otimização. Exército Brasileiro. Programação não linear inteira.

ABSTRACT: The permanent change of station (PCS) of the Brazilian Army military among the various Military Organizations (OM), these grouped in the so-called garrisons in several cities, is an activity carried out annually by the Directorate of Personnel and Movement Control (DCEM), which aims to meet, in the best possible way, the needs of the Force and the interests of the military. To optimize the relocations of the military, this article presents the development of a mathematical model, based on a problem of resource allocation, and compares his results with those presented by the Decision Support System for Movements (SADMov), currently in use, which is based on a constructive algorithm. Computer experiments were carried out for a sample of 277 lieutenants of the Infantry, 374 garrisons and 912 military organizations. The results of optimizations indicate a positive attendance of 121% for the military and 34% for the OM.

KEYWORDS: Personnel relocation. Allocation Problem. Optimization. Brazilian Army. Integer nonlinear programming.

1. Introduction

According to art. 2 of Decree No. 2040, of October 21, 1996, "The military is subject, as a result of the duties and obligations of military activity, to serve in any part of the country or abroad", which makes the existence of a body within the scope of the Armed Forces necessary to manage these movements.

The Directorate for Control of Personnel and Movements (DCEM - Diretoria de Controle de Efetivos e Movimentações), subordinated to the General Department of Personnel (DGP - Departamento-Geral do Pessoal), is the body responsible for the movement of career soldiers in the Brazilian Army. There are approximately 60 thousand military personnel, to be distributed in almost 1,000 military organizations (MO), throughout the national territory, in addition to missions abroad. To fulfill this purpose, DCEM developed two products: the Army Movement Registry (CAMEx - Cadastro de Movimentações do Exército) and the Army Move-

ment Algorithm. [1]

CAMEx consists of a registration system for movement, mandatory for military personnel who have completed the minimum time for movement. In it, the garrison options are initially allocated by the DCEM, and the military can rearrange them according to their priorities. This shared management tool allows DCEM to have a vision of the interests of each soldier in terms of their movement. [1]

The Army Movements Algorithm, used to assist in DCEM decision-making, seeks to optimize movements, considering three main factors: the need for the Force, the interest of the military (according to CAMEx) and meritocracy. [1]

CAMEx and the Algorithm automated what was done manually. The biggest advantages of this process are the speed, the reduction of human interference in decisions, the increase in staff productivity and the facilitation of audits at all stages.

In this scenario, the aim of this article is to present three mathematical models, two single-objectives and one multi-objective, to optimize the movements of Brazilian Army soldiers. The problem is one of allocation and aims to meet the human resource needs of the MO and the interests of the military, regarding their movement options.

This article is structured in six sections: this introduction, literature review, methodology, case study, analysis and discussion of results and conclusions.

2. Literature review

Pentico [11] makes a systematic review of the literature regarding the variations of the classic allocation problem that have arisen since the publication of Kuhn's article [9], on the use of the Hungarian method for its resolution, recognized as the study that highlighted this type of problem, initiating further research on this subject.

The original allocation problem (AP) consists of finding a one-to-one correspondence between tasks and agents in order to minimize the total cost of allocations. [11]

The most common variation of this problem is the Generalized Assignment Problem (GAP), an NP-hard combinatorial optimization problem that consists of finding the minimum cost of allocating n tasks to m agents, in which each task is allocated to exactly one agent, considering the capabilities of each agent. [5] To solve this problem, exact and heuristic algorithms have been proposed. Among the exact methods, one can cite the work of Savelsbergh [12], which uses a branch-and-price algorithm, and that of Nauss [10], which provides for the use of a branch-and-cut algorithm. Ceselli and Righini [4] and Avella et al. [2] also used them in their work, however, applied to a variation of the GAP, the Multilevel Generalized Assignment Problem (MGAP), in which agents can perform tasks according to different levels of efficiency, which have different costs.

However, most works in the literature for this type of problem use heuristics and meta-heuristics as a solution method. This fact is mainly due to the complexity of the problem and the existing availability of computational resources.

Díaz and Fernández [6] propose the Tabu Search meta-heuristic for solving GAP problems. The algorithm uses memory to dynamically adjust the weight of the penalty incurred for violating feasibility. The main differentials of this algorithm are its simplicity and flexibility, which make it, when compared to other heuristics, obtain quality solutions in competitive computational time.

Yagiura et al.[18] also use Tabu Search, with an ejection chain approach, which produces a restricted set of moves, related to building the neighborhood from an initial solution. The algorithm uses a mechanism to adjust search parameters and maintain a balance between visits in viable and non-viable regions.

Tkatek et al. [14] studied a way to optimize the reallocation of human resources in an organization with several production units, geographically distributed, considering their individual characteristics. The study has two stages: first, formulating the problem, starting from the basics of the GAP and adding other restrictions to characterize it;