Metaheuristics

LUISA MARÍA ÁLVAREZ GARCÍA

TU LOGO AQUÍ

VND

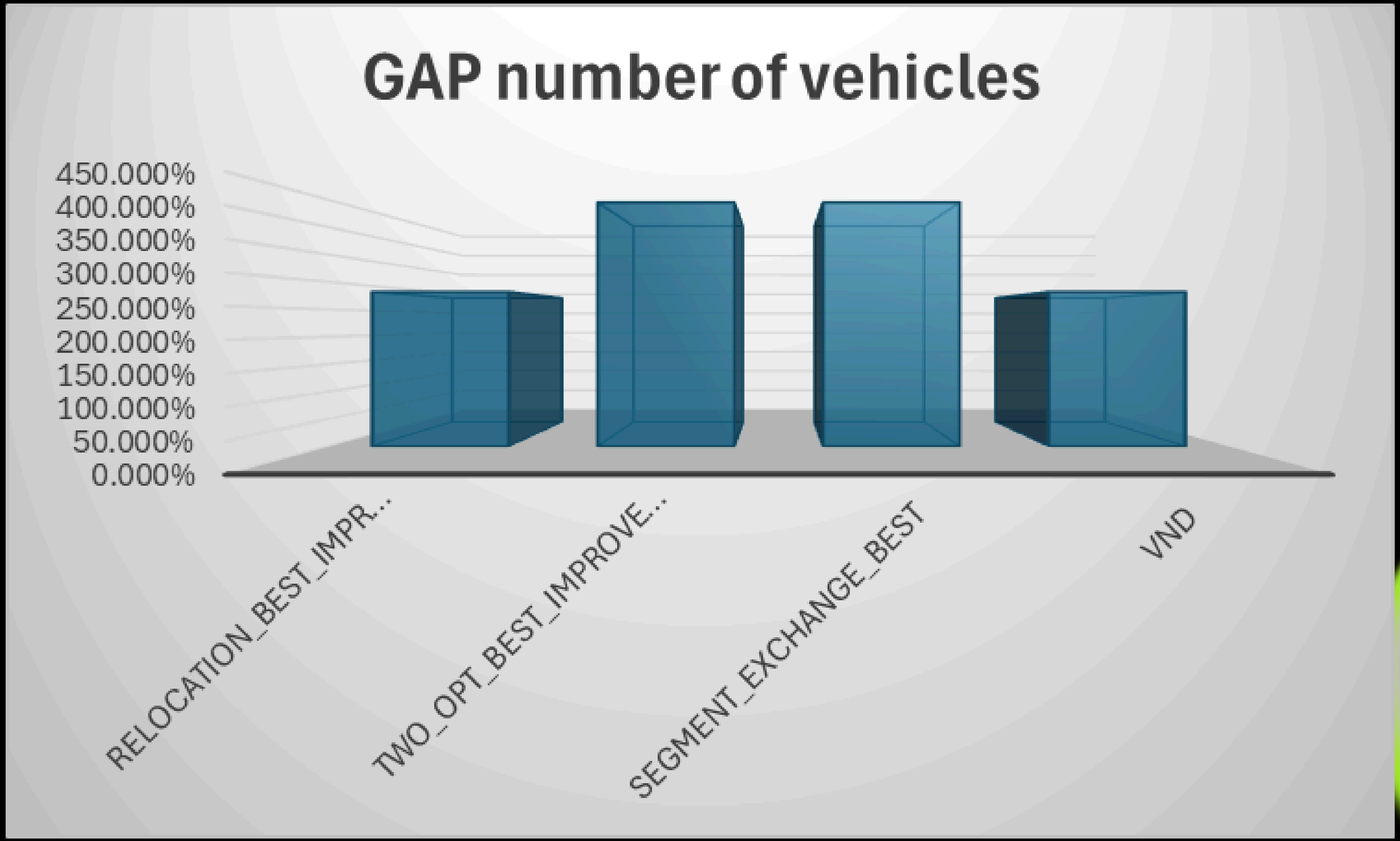
This algorithm improves solutions to the VRPTW by systematically exploring different neighborhoods of solutions to find better routes for vehicles. In this case were used different neighborhoods, there is an overview:

- **Relocation Neighborhood**: Move a node (customer) within or between vehicle routes to improve route- efficiency by optimizing node positions.
- **Two-Opt Neighborhood:** Eliminate crossings in vehicle routes to reduce overall travel distance by refining route structure.
- **Segment Exchange Neighborhood:** Exchange segments between two vehicle routes by leveraging strengths of different vehicles.

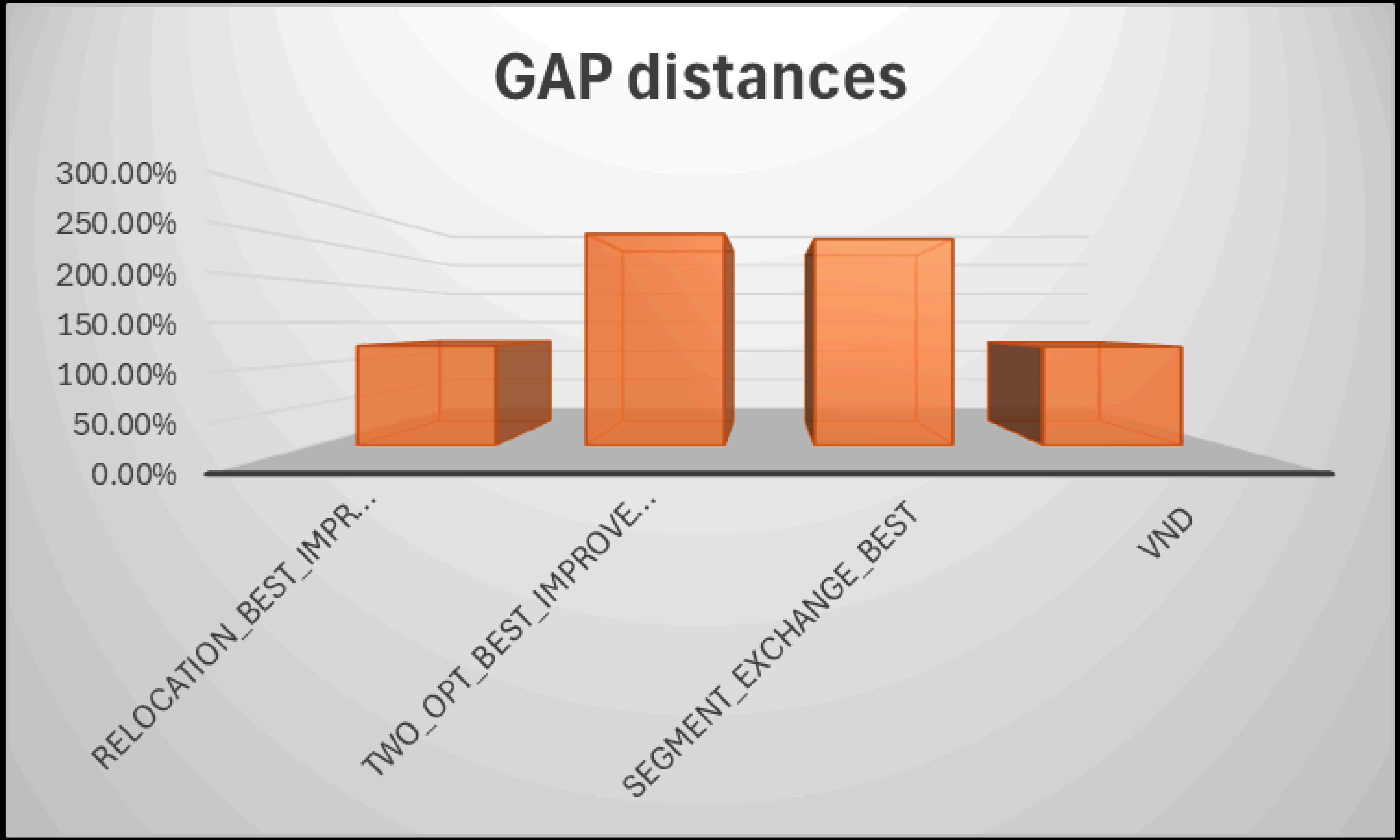
Specifications

- The process of creating the initial solution has a time complexity of $O(n^2)$, where n represents the number of nodes. This involves evaluating each node against others for feasibility.
- Each neighborhood operation, whether it's Relocation, Two-Opt, or Segment Exchange, can range from $O(n^2)$ to $O(n^3)$, depending on the size and complexity of the routes being altered.
- The number of iterations in the Variable Neighborhood Descent (VND) can fluctuate, potentially resulting in exponential complexity in the worst-case scenario; however, it typically performs much more efficiently in practice.

GAP VEHICLES USED



GAP DISTANCES



METHOD CONCLUTIONS

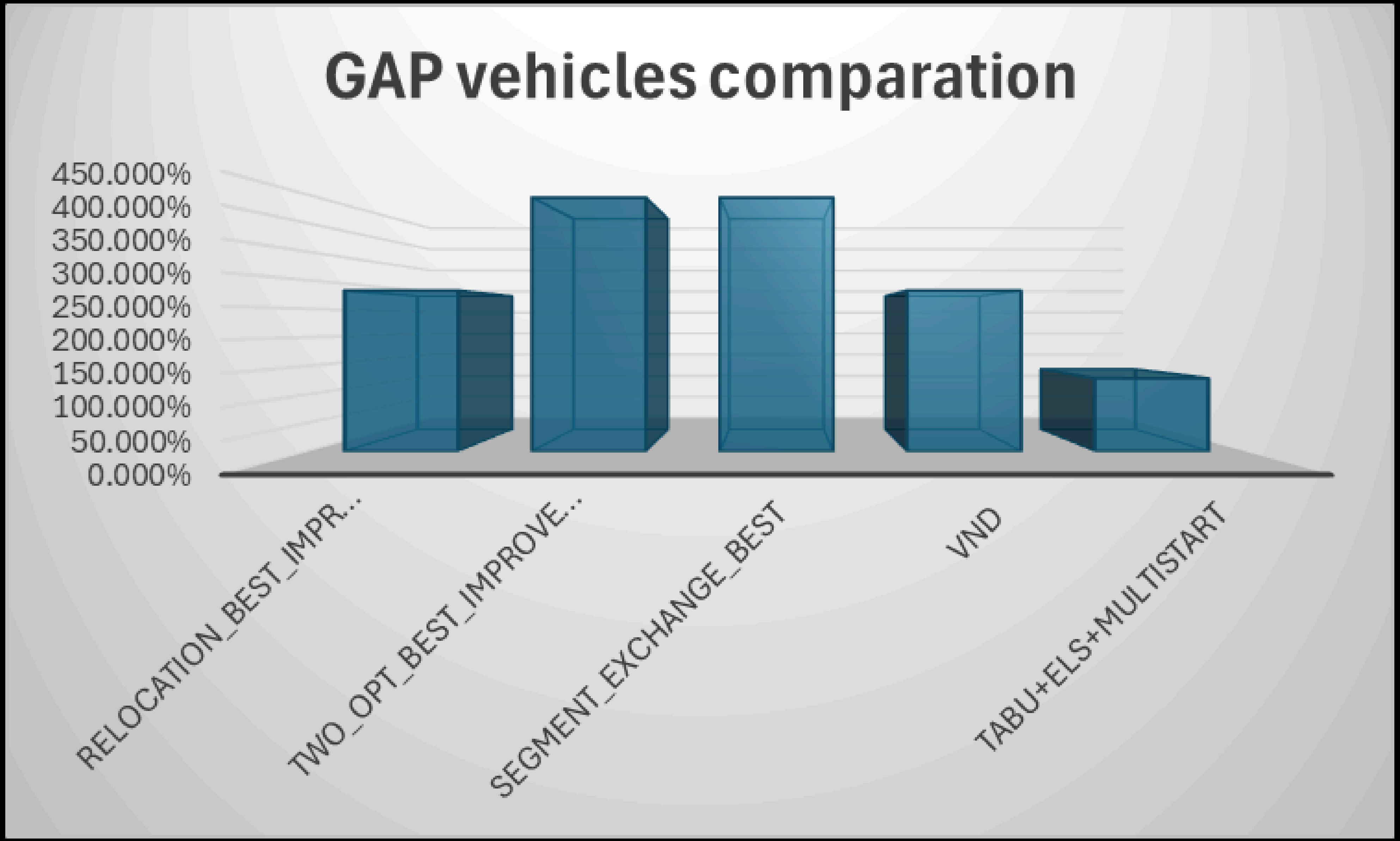
Algorithm	Vehicles avg	Distance avg
relocation_best_improvement	281.836%	121.62%
two_opt_best_improvement	444.861%	258.27%
segment_exchange_best	444.861%	251.86%
VND	281.836%	120.33%

- The use of relocalization, two-optimal and segment-swapping algorithms allows for a more exhaustive exploration of the solution space, which allows one to escape from local optima.
- Include more neighborhoods that can represent optimizations for the program, for example node exchange or insertion, ensuring that the new solutions are valid, or improving the exchange of segments.
- Although VND represents a substantial improvement over the other methods, it does not do so in a very representative way. This may be due to the fact that the neighborhood algorithms found within it are not very optimal, as can be seen in the gap. For this, the solution could be to change these neighborhoods for others that generate better results.

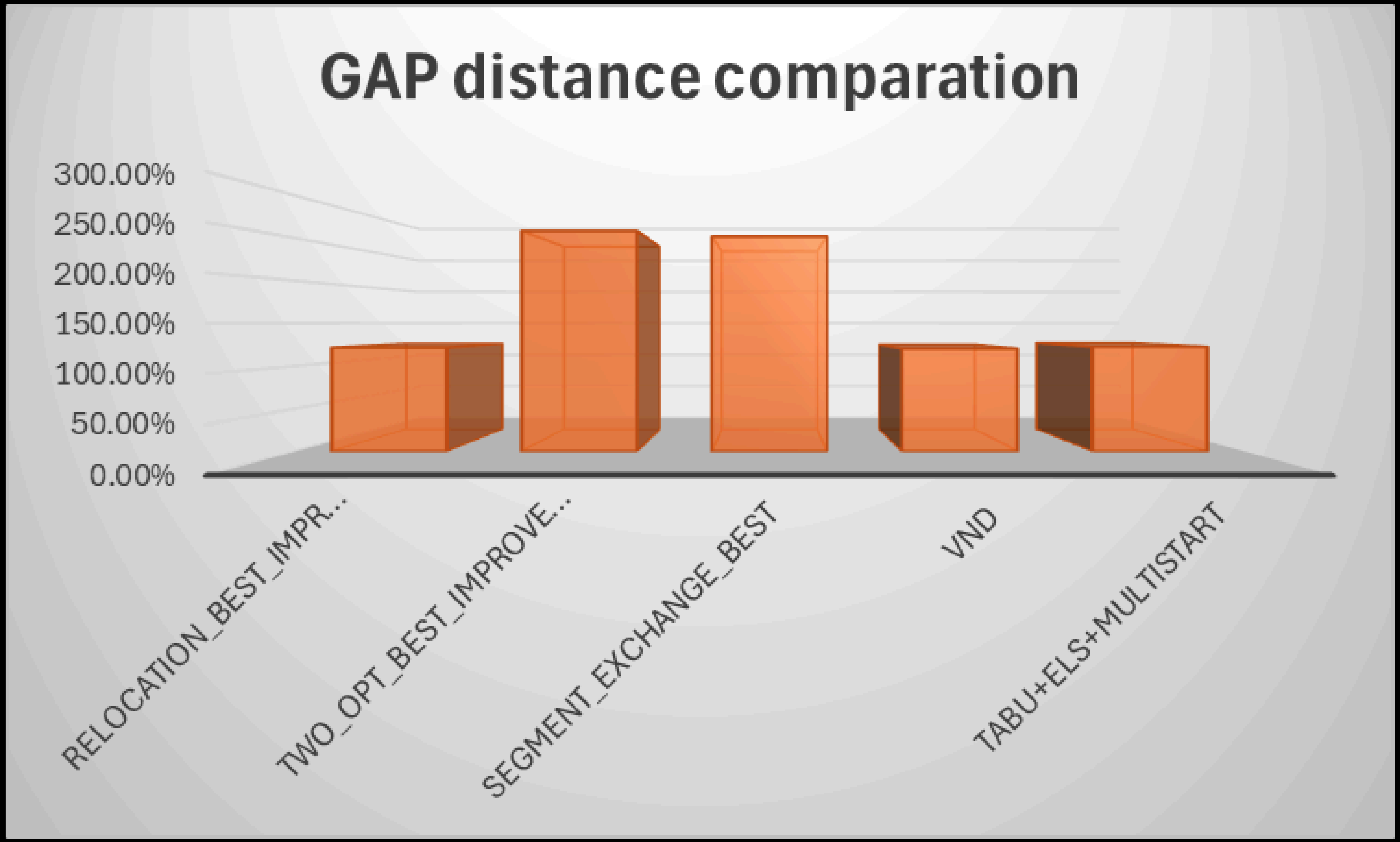
Tabu Search, ElS, Multistart algorithm

Tabu search, local improvement approach (ELS), and multi-start are techniques that significantly increase the effectiveness of constructive solutions for VRPTW by avoiding local optima, diversifying the search, and exploring multiple solution configurations. Without these techniques, a constructive approach can get stuck in suboptimal solutions, limiting the ability to find the best possible route. Tabu search helps prevent cycles in solution exploration, ELS iteratively improves the current solution, and multi-start allows for multiple construction attempts, increasing the chances of discovering more efficient routes that meet problem constraints.

GAP VEHICLES COMPARATION



GAP DISTANCES COMPARATION



METHOD CONCLUTIONS

- The algorithm demonstrates that the combination of ELS, multistart and Tabu search can show more effective results compared to two-opt and segment exchange, and although it is effective, it may not be as aggressive in optimizing as more specialized approaches.

- Vehicle Usage Efficiency: The fact that the Tabu+ELS+multistart approach maintains an average number of vehicles at 128.02% indicates a relatively good efficiency in resource use. This can be advantageous in the case where reducing operational costs is critical.

- Since other techniques present more significant improvements in terms of distances and vehicle usage, it would be beneficial to investigate how to integrate aspects of these more effective methodologies (such as two-opt or segment exchange improvements) into the Tabu+ELS+multistart approach to increase overall effectiveness.

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VND	281.836%	120.33%
Tabu+ELS+multistart	128.020%	122.58%

GENERAL CONCLUTIONS

- With a 281.84% increase in vehicles and 120.33% in distance, VND shows effectiveness, but its ability to improve is limited compared to other methods.

- This approach, with a 128.02% increase in vehicles and 122.58% in distance, achieves a balanced solution, offering a significant improvement compared to VND.

- Although VND shows good results, the combined approach is more efficient in optimizing both the number of vehicles and the distance traveled.

- Despite its achievements, VND presents considerable room for improvement in terms of distance, suggesting that it can benefit from additional techniques such as tabu search.