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A Stage-Gate Decision Architecture for Freight–Passenger Integration in Urban Public Transport Systems

[1] Leonardo da Silva Ribeiro, [1] Rômulo Orrico, [2] Cíntia Machado
[1] Transport Engineering Program, COPPE, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil
[2] Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET-RJ), Rio de Janeiro, Brazil

INTRODUCTION & AIM

Research Motivation

Urban public transport systems are traditionally designed exclusively for passenger mobility, while their latent operational capacity remains underexplored as a strategic resource for urban logistics. Recent studies on freight–passenger integration have mainly focused on isolated operational experiments and feasibility analyses, with limited attention to structured decision-making processes capable of managing technical, operational, economic, and institutional uncertainties.
As cities face increasing pressure from e-commerce growth, congestion, and infrastructure constraints, there is a growing need for analytical frameworks that support systematic evaluation of shared infrastructure strategies in urban transport systems.

Research Objective

This study proposes a Stage-Gate diagnostic framework grounded in Engineering Methods and Design Science Research to support analytically structured go/no-go decisions for freight integration into Bus Rapid Transit (BRT) systems.
The framework structures feasibility assessment through sequential validation gates covering territorial, operational, service, economic, and governance dimensions.

METHOD

Stage-Gate Decision Architecture

The framework conceptualizes freight integration into BRT systems as a progressive validation process designed to reduce operational and institutional uncertainty. Through sequential analytical gates, the model integrates technical, logistical, economic, and governance dimensions into a unified decision-support architecture for infrastructure sharing in urban transport systems.

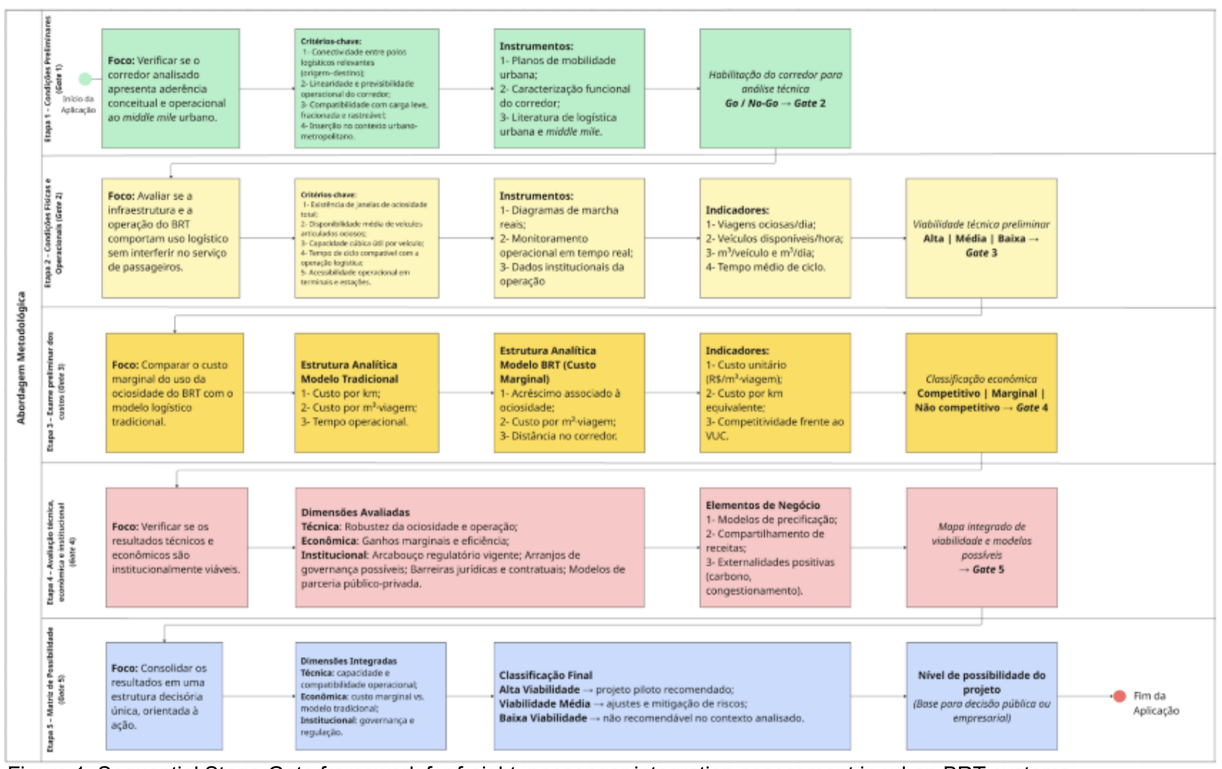

Figure 1. Sequential Stage-Gate framework for freight–passenger integration assessment in urban BRT systems.

RESULTS & DISCUSSION

Empirical Findings

- Stable off-peak idle capacity identified in the TransCarioca corridor.
- Operational windows compatible with middle mile logistics activities.
- Freight integration potential without significant passenger service interference.
- Existing BRT infrastructure demonstrates latent logistical capability under controlled operational conditions.

Strategic Interpretation

The results indicate that freight–passenger integration should not be interpreted solely as an operational adaptation, but as a broader infrastructure-sharing strategy capable of improving urban transport efficiency and supporting sustainable logistics systems.
The Stage-Gate framework demonstrated the ability to organize feasibility assessment under technical, economic, operational, and institutional uncertainty, supporting analytically structured go/no-go decisions prior to implementation.

Main Contribution

The study advances the literature by shifting freight–passenger integration analysis from isolated feasibility experiments toward a structured decision architecture grounded in Engineering Methods and Design Science Research.

CONCLUSION

The proposed Stage-Gate framework provides a structured and transferable decision-support architecture for assessing freight–passenger integration in urban public transport systems. By organizing feasibility evaluation through sequential validation gates, the model enables systematic analysis of technical, operational, economic, and institutional conditions before implementation.
The application to the TransCarioca BRT corridor demonstrated the existence of stable off-peak operational capacity that could potentially support middle mile logistics activities without compromising passenger service reliability.
Beyond the empirical case, the study contributes to the advancement of infrastructure-sharing and urban logistics literature by integrating uncertainty management, governance analysis, and operational assessment into a unified methodological framework grounded in Engineering Methods and Design Science Research.

FUTURE WORK / REFERENCES

- Pilot implementation in operational BRT environments
- Real-time freight allocation models
- Multi-corridor scalability assessment
- Integration with digital urban logistics platforms
- Comparative applications in other public transport systems

Ribeiro, L.d.S.; Orrico, R.; Oliveira, C.M.d. *BRT in the Middle Mile: A Potential Urban Logistics Platform*. Urban Science, 2025, 9(11), 438. https://doi.org/10.3390/urbansci9110438