Information Design and Wayfinding in urban bus transit: the case of São Luís, MA, Brazil

Design da Informação e Wayfinding no transporte urbano por ônibus: o caso de São Luís, MA, Brasil

Bruno Serviliano Santos Farias, Cristiano Frazão de Oliveira Silva

information design,
wayfinding,
universal design,
public transportation,
informational accessibility

This article evaluates the communicational efficiency of the urban bus transport system in São Luís, Brazil, through the lenses of Information Design, Wayfinding, and Universal Design. The study follows an exploratory approach, combining in-situ heuristic observation and documentary analysis of informational artifacts, based on ten heuristics adapted from Nielsen (1994), Calori & Vanden-Eynden (2015), and Pettersson (2002). A total of 23 observational records were collected across the stages of the user journey – planning, access, waiting, boarding, in-vehicle travel, and alighting – allowing the identification of recurrent failure patterns and design opportunities. Findings reveal three critical clusters of communication problems: (H4) insufficient legibility, (H10) absence of multimodal redundancy, and (H3) inaccurate or outdated information. These failures reduce users' informational autonomy and system trustworthiness, disproportionately affecting individuals with low schooling, older adults, and those in informational vulnerability. The study contributes a replicable heuristic protocol and a set of practical design guidelines to enhance legibility, multimodal redundancy, and information governance. It underscores the role of Information Design as a mediator of communicational accessibility, promoting user autonomy and trust in public transport. The research is limited by its small purposive sample and the absence of direct user testing, suggesting future studies incorporating quantitative and participatory methods to strengthen empirical evidence.

*design da informação,
wayfinding,
design universal,
transporte público,
acessibilidade informacional*

Este artigo avalia a eficiência comunicacional do sistema de transporte coletivo urbano de São Luís, Brasil, sob as perspectivas do Design da Informação, Wayfinding e Design Universal. O estudo adota uma abordagem exploratória, combinando observação heurística in loco e análise documental de artefatos informacionais, com base em dez heurísticas adaptadas de Nielsen (1994), Calori & Vanden-Eynden (2015) e Pettersson (2002). Um total de 23 registros observacionais foi coletado ao longo das etapas da jornada do usuário – planejamento, acesso, espera, embarque, deslocamento e desembarque –, permitindo a identificação de padrões recorrentes de falhas e oportunidades de aprimoramento no design. Os resultados revelam três agrupamentos críticos de problemas de comunicação: (H4) legibilidade insuficiente, (H10) ausência de redundância multimodal e (H3) informação imprecisa ou desatualizada. Essas falhas reduzem a autonomia informacional dos usuários e a confiabilidade do sistema, afetando de forma desproporcional indivíduos com baixa escolaridade, pessoas idosas e aqueles em situação de vulnerabilidade informacional. O estudo contribui com um protocolo heurístico replicável e um conjunto de diretrizes

práticas de design voltadas à melhoria da legibilidade, da redundância multimodal e da governança da informação. Destaca-se o papel do Design da Informação como mediador da acessibilidade comunicacional, promovendo a autonomia e a confiança do usuário no transporte público. A pesquisa apresenta limitações relacionadas ao tamanho reduzido da amostra e à ausência de testes diretos com usuários, sugerindo que estudos futuros incorporem métodos quantitativos e participativos para fortalecer as evidências empíricas.

1 Introduction

For a large portion of the Brazilian population, urban bus transport represents the main mediator of the right to mobility. In cities such as São Luís (MA), its efficiency depends not only on physical and operational infrastructure but also on the quality of the visual communication that guides passengers through each stage of the journey – locating the stop, identifying the route, deciding on transfers, monitoring the trip, and recognizing the correct alighting point. This informational layer – composed of maps, destination signs, colors, pictograms, audible announcements, and display panels – constitutes what the literature defines as a *wayfinding system*, whose function is to reduce uncertainty and support decision-making in complex environments (Arthur & Passini, 1992; Calori & Vanden-Eynden, 2015).

Within the field of Information Design, principles such as clarity, concision, hierarchy, and consistency are fundamental to reduce cognitive load and increase the accuracy of user decisions (Tufte, 1990; Pettersson, 2002). In dynamic contexts – such as boarding a moving bus – typographic legibility, figure-ground contrast, and multimodal redundancy (text, color, pictogram, and audio) become essential requirements to ensure rapid and safe message perception (Mayer, 2009; Garvey, 2015; Lupfer, 2016). When these conditions fail, informational gaps emerge, forcing passengers to seek help from others and increasing the risk of errors, delays, and even withdrawal from the system.

These challenges are even more critical for groups in informational vulnerability, such as children, older adults, and people with low schooling or limited functional literacy. For these users, Universal Design recommends solutions that promote equitable use, information perceptible through multiple senses, and low cognitive and physical effort (Story, Mueller, & Mace, 1998; Connell et al., 1997). In public transport, this implies measures ranging from the standardization of pictograms and nomenclatures to the inclusion of audible announcements and simplified maps that are easy to understand.

Based on this context, the present study investigates the communicational efficiency of the urban bus transport system of São Luís (MA), adopting the perspectives of Information Design, Wayfinding, and Universal Design. The overall objective is to assess the informational performance of the system throughout the user journey (planning, access, waiting, boarding, in-vehicle travel, and alighting), identifying design shortcomings and their practical effects. Specifically, the study aims to:

a) map identity and informational elements present in stops, terminals, and vehicles;
b) diagnose barriers related to legibility, accuracy, and consistency; and
c) propose design improvements aligned with the principles of Information Design, Wayfinding, and Universal Design.

The research has an exploratory nature and a reduced purposive sample, composed of *in-situ* observational records. Its scope does not allow for statistical generalization but provides empirical evidence that can support the formulation of replicable design guidelines for other urban contexts. Thus, the study contributes both to the theoretical advancement of Information Design and to the practical enhancement of signage systems aimed at inclusive urban mobility.

2 Theoretical framework

Information Design (ID) structures and organizes content to support comprehension, decision-making, and task performance, aiming to reduce user uncertainty through clarity, consistency, hierarchy, and concision (Frascara, 2004; Pettersson, 2002; Tufte, 1990). In transport systems, ID materializes as networks of visual and auditory cues – maps, signs, route indicators, and displays – that compose the *wayfinding* ecosystem, the set of environmental and graphic elements that help people orient themselves, decide, and move autonomously (Arthur & Passini, 1992; Calori & Vanden-Eynden, 2015).

Wayfinding literature emphasizes that spatial decisions are situational and time-dependent; thus, the design of informational messages must align content, form, and placement with the user's decision stage (Arthur & Passini, 1992). In dynamic contexts – such as boarding and in-vehicle travel – typographic legibility, color contrast, and message stability become essential for safe and efficient information processing (Garvey, 2015; Lupfer, 2016). Legibility relates to the perceptual clarity of characters and symbols, while readability concerns the syntactic fluency of text blocks (Pettersson, 2002). Both dimensions are necessary to ensure accessible information for diverse users.

Color and pictograms play complementary roles: color supports information hierarchy and route identification, while pictograms reduce dependence on textual literacy, provided they are semantically clear and culturally validated (Mijksenaar, 1997; Calori & Vanden-Eynden, 2015). Maps and diagrams, in turn, must balance detail and abstraction, providing macro views for trip planning and micro views for orientation during movement (Tufte, 1990; Pettersson, 2002).

Universal Design introduces seven principles that advocate equitable, perceptible, and low-effort access to information and the built environment (Connell et al., 1997; Story, Mueller, & Mace, 1998). In the context of public communication, these principles translate into multimodal redundancy – that is, the simultaneous use of distinct representational channels (visual,

auditory, textual, and chromatic) to reinforce message comprehension (Mayer, 2009; Wickens, 2008).

The term "multimodal redundancy" is adopted here, rather than "multisensory redundancy," because it more precisely denotes the integration of different modes of representation rather than the stimulation of multiple senses.

Recent research highlights that combining visual and auditory channels improves comprehension and short-term memory in environments with divided attention, such as moving vehicles (Lidwell, Holden, & Butler, 2010; Seva, 2021). In public transport, audible next-stop announcements and static visual indicators enhance informational autonomy and reduce anxiety, particularly for users with low schooling or low vision (Fernandes et al., 2022; Yoon et al., 2023). These measures exemplify how Universal Design principles operationalize Information Design strategies in real mobility contexts.

Originally proposed by Nielsen (1994) for digital interface evaluation, heuristics are concise, experience-based rules that help assess design quality through observable criteria such as clarity, consistency, accuracy, and feedback. In Information Design, heuristic evaluation serves as a systematic yet flexible approach to identify communication problems without requiring extensive user testing.

When adapted to public information systems, heuristics bridge the theoretical principles of usability and the practical challenges of environmental communication (Calori & Vanden-Eynden, 2015). This approach aligns with Frascara's (2004) view of design as a mediating discipline focused on user understanding rather than aesthetic form.

In this study, the choice of heuristics – rather than "criteria" or "guidelines" – is intentional. While criteria and guidelines prescribe desired design outcomes, heuristics enable diagnostic analysis, allowing evaluators to interpret how communication artifacts perform in real use conditions. This diagnostic lens is particularly useful in complex, dynamic settings like urban transport, where observation replaces laboratory testing.

The heuristic framework used here adapts the principles of Nielsen (1994), Calori & Vanden-Eynden (2015), and Pettersson (2002) to the specific context of transit communication, encompassing ten categories that synthesize central principles of Information Design, Wayfinding, and Universal Design:

Table 1 Heuristics.

Heuristic	Reference/Origin	Definition
H1 – Clarity and concision	Nielsen (1994); Pettersson (2002)	Ensures that information is immediately understandable to users of different literacy levels.
H2 – Visual consistency	Calori & Vanden-Eynden (2015); Tufte (1990)	Maintains uniform visual language and coding throughout the system.
H3 – Accuracy/Objectivity	Nielsen (1994); Frascara (2004)	Provides correct, up-to-date, and unambiguous information.

Table 1 Heuristics. (continued)

Heuristic	Reference/Origin	Definition
H4 – Legibility	Garvey (2015); Pettersson (2002)	Ensures that text and symbols can be read and distinguished under real viewing conditions.
H5 – Symbols/Pictograms	Mijksenaar (1997); Calori & Vanden-Eynden (2015)	Uses universal pictograms and icons that communicate quickly and cross-culturally.
H6 – Information panels	Arthur & Passini (1992); Frascara (2004)	Provides a robust, concise, and accessible set of information at key decision points.
H7 – Spatial orientation	Arthur & Passini (1992); Calori & Vanden-Eynden (2015)	Facilitates user navigation in complex environments.
H8 – Functional color use	Pettersson (2002); W3C (2018)	Employs color for functional differentiation and accessibility, ensuring adequate contrast.
H9 – Signage hierarchy	Calori & Vanden-Eynden (2015)	Organizes messages according to task relevance and spatial sequence.
H10 – Information structure and multimodal redundancy	Mayer (2009); Wickens (2008); Connell et al. (1997)	Integrates text, color, icon, and audio channels to reinforce comprehension and inclusivity.

Integrating these three domains provides a holistic framework for evaluating and improving public communication systems. Information Design supplies the principles of message structure and clarity; Wayfinding adds spatial and contextual understanding; and Universal Design ensures perceptibility, equity, and usability for all audiences.

This triadic approach is increasingly present in contemporary design research on inclusive mobility (Fernandes et al., 2022; Yoon et al., 2023), where informational accessibility is considered a key dimension of social inclusion. By applying heuristics to real environments, this study operationalizes those connections, translating theoretical principles into practical evaluation tools.

3 Context of public transport in São Luís

The public transport system of São Luís is predominantly bus-based and operated by private companies under municipal regulation, integrated into the Integrated Transport System (SIT). Since the 1990s, the SIT has organized the network around transfer terminals and multiple interconnected routes with a single fare, allowing door-to-door travel with transfers between different lines (São Luís, 1996).

In 2024, the Municipality of São Luís reported five integration terminals (Cohab/Cohatrac, Distrito Industrial, Praia Grande, São Cristóvão, and São Francisco) and 131 integrated routes, underscoring the central role of buses in the city's urban mobility (Transparência São Luís, 2024). The system serves the majority of the city's daily trips, constituting an essential component of the right to urban mobility.

From a socioeconomic perspective, educational indicators reveal a heterogeneous reality. According to the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística [IBGE], 2024), residents aged 25 and older have an average of 11.5 years of schooling, while approximately 155,000 people aged 14 or older have not completed primary education. Among them, around 33,000 are illiterate (IBGE, 2023). This condition highlights the importance of accessible communication solutions that consider the diversity of literacy levels and cognitive abilities among public transport users.

Operationally, studies and local surveys indicate that, although there has been a gradual expansion of the bus fleet in recent decades, challenges remain regarding vehicle age and irregular maintenance (Carvalho Junior et al., 2015). Recent user experience research reports an average travel time of 33 minutes, with 1.3 transfers per trip, and negative evaluations of terminal conditions, such as overcrowding and poor infrastructure (Siqueira & Farias Filho, 2020). These conditions increase the cognitive load of the journey, making the clarity and reliability of passenger information systems – including signage, maps, and display panels – critical for real-time decision-making.

Visually and normatively, Municipal Ordinance No. 0245/2016 (São Luís, 2016) standardized the external layout of buses, defining citrus yellow as the dominant color and establishing a unified coding scheme to facilitate vehicle identification and reduce ambiguities in line recognition.

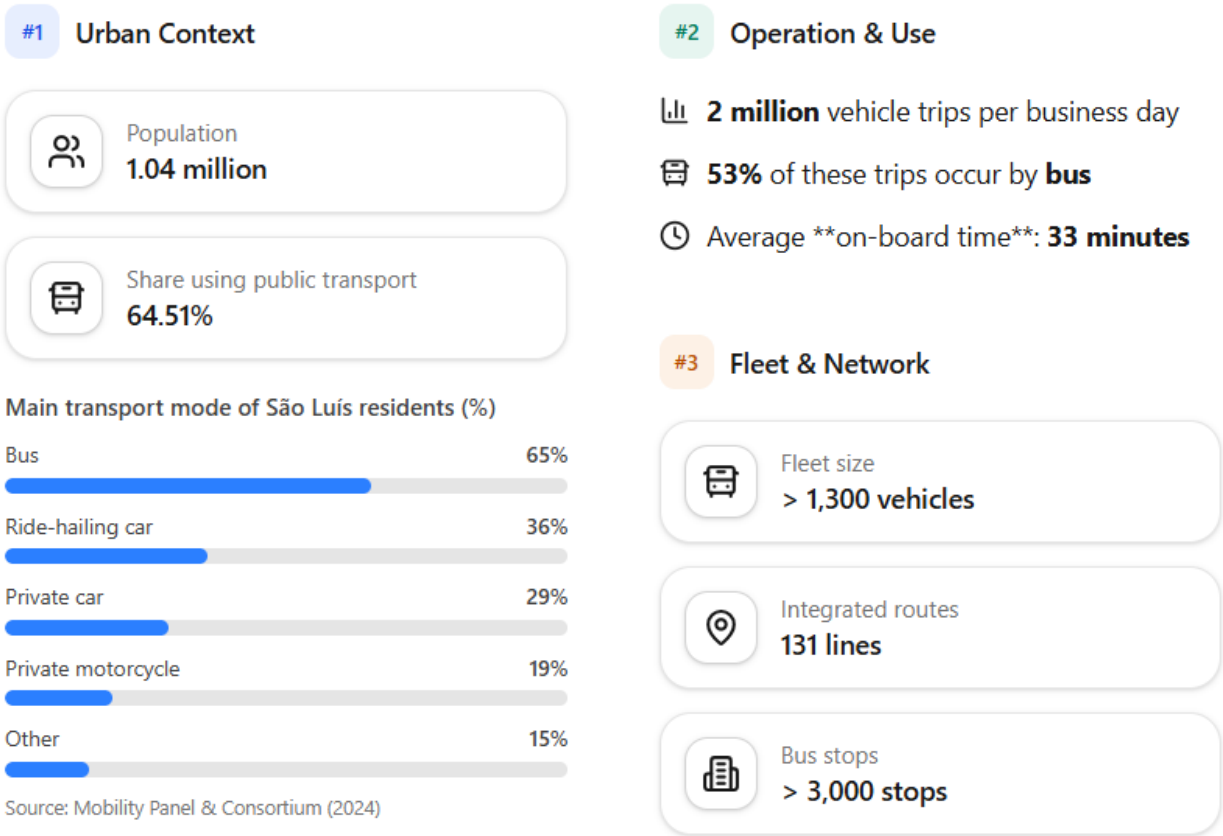


Figure 1 Infographic of the São Luís public transport system.

However, field observations reveal inconsistencies in the implementation of these standards, particularly regarding typographic legibility and color coherence among operators, which compromise the communicational efficiency of the system.

Therefore, the context of São Luís reflects an unequal and informationally vulnerable urban environment, where the effectiveness of public transport depends not only on operational aspects but also on the quality and accessibility of informational communication available to passengers. This reality underscores the relevance of adopting Information Design, Wayfinding, and Universal Design principles in analyzing and redesigning the system's visual communication.

4 Methodology

This study adopts an exploratory case study design focused on evaluating the communicational efficiency of São Luís's urban bus information system. The research combines systematic field observation and documentary analysis of visual and regulatory materials, grounded in theoretical frameworks from *Information Design*, *Wayfinding*, and *Universal Design* (Arthur & Passini, 1992; Calori & Vanden-Eynden, 2015; Frascara, 2004; Pettersson, 2002; Connell et al., 1997; Story, Mueller, & Mace, 1998).

The empirical investigation was structured according to the Heuristic Evaluation method originally proposed by Nielsen (1994) for digital interfaces and later adapted to public communication systems (Calori & Vanden-Eynden, 2015; Pettersson, 2002). In this approach, an evaluator systematically inspects information artifacts using a set of pre-established heuristics – principles that serve as diagnostic guides to identify design problems based on clarity, consistency, accuracy, and accessibility.

Heuristic Evaluation is particularly appropriate in complex public environments – such as transport systems – where traditional user testing is constrained by ethical, logistical, or safety considerations. It enables the identification of communication barriers under real operating conditions, offering a rapid and cost-effective diagnostic overview that informs future user-centered research.

In this study, the ten heuristics defined in Section 2 (H1–H10) were applied to assess the visual and informational performance of artifacts within the user journey: trip planning, access to the stop, waiting at the stop or terminal, boarding, in-vehicle travel, and alighting. Each heuristic was treated as an analytical dimension, guiding the observation and classification of design issues.

A purposive (intentional) sampling strategy was employed to ensure coverage of the main journey stages and typological variation in the system – radial and inter-neighborhood routes, stops with and without shelters, transfer terminals, and vehicles with static and electronic signage. The empirical corpus comprises 23 observational records, each representing a real-world interaction between a user and an informational artifact (e.g., bus stop sign, route map, LED display, or on-board notice).

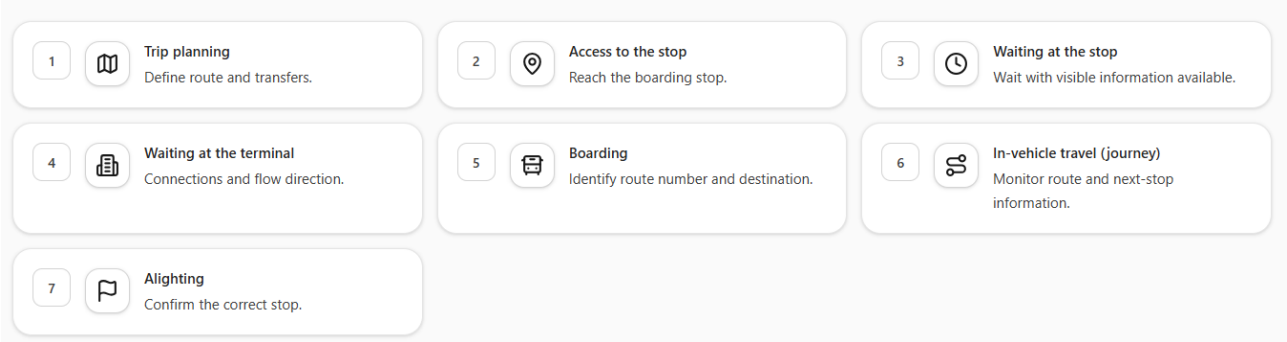


Figure 2 Research stages.

The term "record" refers to a situated observation event, not to an individual user. The focus of the analysis lies in the communication artifacts themselves, evaluated from the standpoint of an informed observer, rather than direct participant users. No personal data were collected, and no interventionist interaction occurred with passengers. The study therefore conforms to ethical standards for non-intrusive observation in public environments.

However, the observations implicitly considered user behavior indicators – for example, moments when passengers appeared disoriented, hesitated before boarding, or sought confirmation from others. These instances were recorded only as contextual cues to interpret the communicational performance of the system, not as psychological or emotional data.

The sampling design thus represents a system-oriented evaluation rather than a user-based test, appropriate for diagnostic purposes in exploratory research.

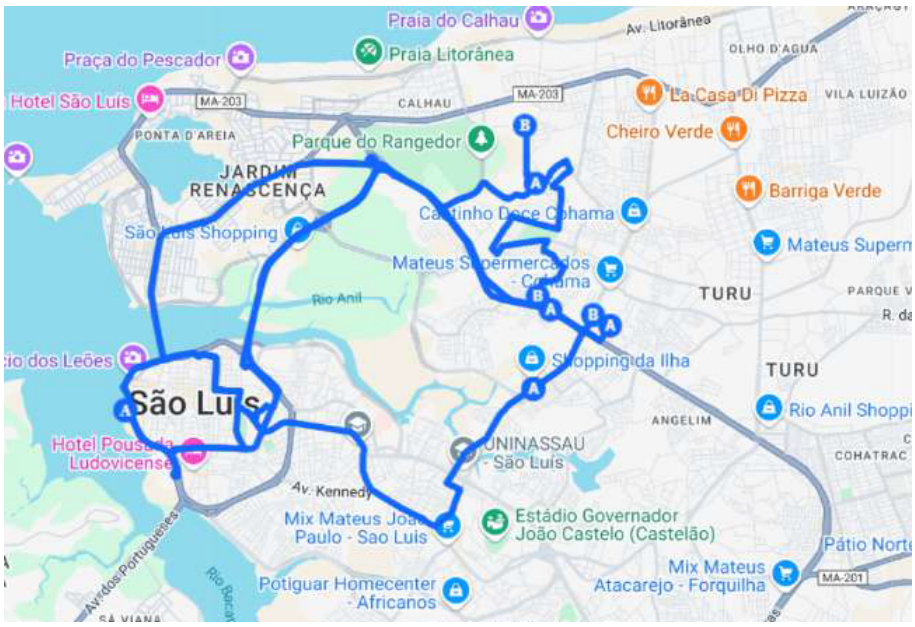


Figure 3 Route covered by the observational records.

Data collection employed a structured observation form containing the following fields:

- Design element observed (sign, panel, headsign, map, etc.);
- Information modality (textual, pictographic, chromatic, auditory);
- User task or informational need (e.g., identify route, confirm destination);
- Observed difficulty or failure;
- Violated heuristic (H1–H10);
- Apparent impact on user autonomy or comprehension;
- Suggested design improvement.

Each observation was accompanied by photographic documentation of the artifact (avoiding the identification of individuals). The evaluator recorded the environmental conditions (lighting, crowding, distance, and vehicle motion) and contextual details relevant to perception and legibility.

The data were subsequently consolidated into a spreadsheet and analyzed through:

1. Descriptive statistics – frequency distributions by journey stage and heuristic category;
2. Stage × Heuristic cross-tabulations – to identify critical touchpoints where failures concentrate;
3. Qualitative content analysis – to interpret recurring patterns or "failure modes" (e.g., illegible electronic displays, outdated terminal maps, absence of audible announcements).

The study did not involve human subject testing, personal data collection, or experimental intervention, and therefore did not require informed consent under Brazilian ethical guidelines for observational research in public spaces. The analysis is diagnostic and exploratory, designed to identify opportunities for improvement rather than to generalize statistically.

Nevertheless, the protocol provides a replicable framework that can be extended to comparative studies in other cities or combined with future user-centered testing, such as usability trials with diverse populations.

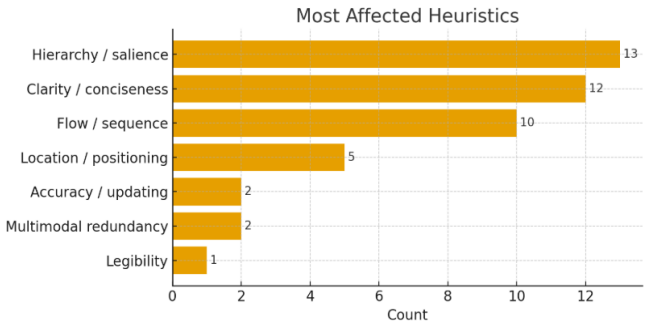
5 Results

A total of 23 observational records were consolidated across the stages of the user journey: trip planning, access, waiting, boarding, in-vehicle travel, and alighting. Each record corresponds to a real-world use event in which an informational artifact of the system (sign, headsign, map, panel, or pictogram) was analyzed according to the set of heuristics defined in Section 2.

Chart 1 presents the distribution of these records across the user journey, indicating the number of observations in which communication failures were identified. The "Count" field represents the number of occurrences recorded in each stage, regardless of the type of artifact evaluated.

Chart 1 Observation data.

Journey stage	Count
Boarding	5
In-vehicle travel (journey)	5
Alighting	5
Access to the stop	3
Waiting at the stop*	3
Waiting at the terminal	2



Descriptive analysis reveals that the highest concentration of failures occurs at decision points under time pressure – particularly during boarding, in-vehicle travel, and alighting. These moments demand rapid information processing, making legibility, contrast, and multimodal redundancy decisive factors for communication success.

The findings indicate three primary heuristic problem clusters, recurring across multiple stages of the journey (Figure 4):

Figure 4 Photographic records.

Data analysed by heuristic categories (Table 2):

Table 2 Analysis of the recorded heuristics.

Heuristic	Observation
Insufficient legibility (H4)	Small type and/or low contrast on signs and headsigns; fast scrolling on LED displays. Effect: late or impossible reading while the bus approaches; users rely on others to confirm route/destination.
Absence of multimodal redundancy (H10)	No next-stop audible announcements; on-board maps/diagrams missing or illegible. Effect: difficulty monitoring the journey; wrong alightings and greater anxiety among low-literacy users.
Inaccuracy/outdated information (H3)	Outdated panels and lists in terminals; inconsistent naming conventions for the same route across media. Effect: distrust of official messages; reliance on "own rules" (bus color, memory of landmarks).
Inadequate placement (H8)	Signs at inaccessible heights/angles; stops without visible guidance within pedestrian flow. Effect: repeated information search, longer paths, and missed departures.
Flow/Sequence and Hierarchy (H9/H5)	Information order does not match the task (e.g., route code emphasized while destination is secondary). Effect: delayed decision-making under time pressure (boarding).
Pictography/Color and Environmental robustness (H6/H7)	Sparse occurrences: unclear icons and signs degraded by weather, impairing legibility at specific locations.

Overall, the most recurrent problems (H3, H4, and H10) cluster around the critical stages of the journey – boarding, in-vehicle travel, and alighting – which coincide with moments of higher cognitive load and time pressure. These findings highlight the importance of adopting distance-based legibility criteria, stable visual messaging, and redundancy between visual and auditory channels.

The observations also reveal deficiencies in information governance, such as the lack of regular updating processes for maps, route lists, and panels. This absence of maintenance undermines both message

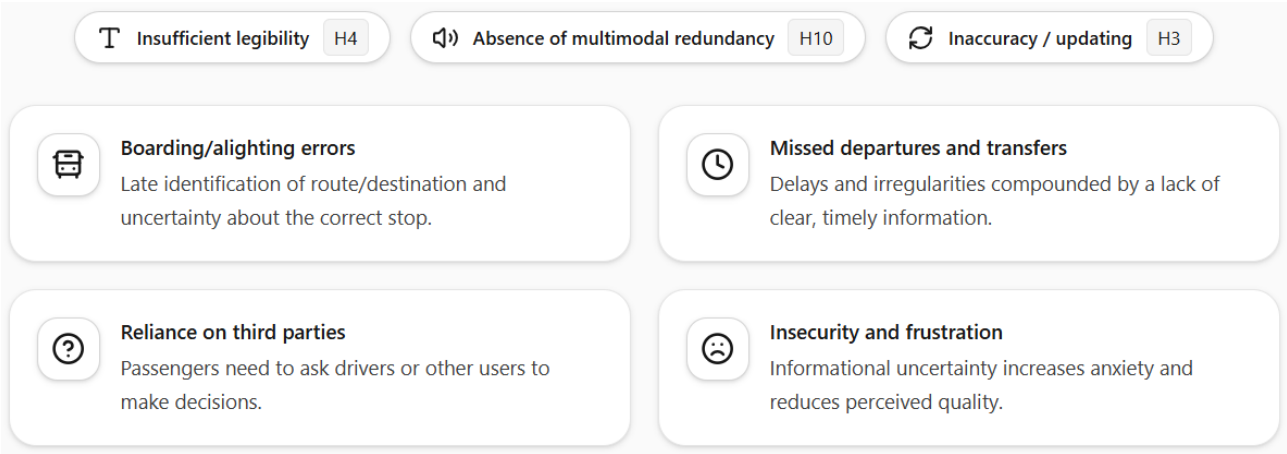


Figure 5 Heuristic problems.

reliability and consistency across different media (vehicles, terminals, and mobile applications).

Finally, the diversity of operators and vehicle fleets accentuates variations in color, typography, and layout, reducing the uniformity of the visual identity prescribed by Municipal Ordinance No. 0245/2016. This graphical heterogeneity hinders user familiarity and weakens rapid line recognition, particularly among those with limited experience or perceptual impairments.

The absence of multimodal redundancy and insufficient legibility generate informational exclusion, constraining users' ability to exercise their right to mobility. Accordingly, the following design recommendations are proposed (Table 3):

Table 3 Suggestions for the São Luís public transport system.

Aspect	Suggestions
Line visual identity	Functional use of line colors as differentiation; lateral and rear bands in the route's dominant color; pictorial and symbolic elements as tools for distinction and informational communication.
Destination display and typography	Show route number and destination in static type, with high contrast and size readable at distance; provide a fixed sign or adhesive vinyl on the front, sides, and rear.
Pictograms and icons	Use universal pictograms for each service (integration, express, circular) placed next to the route number.
Simplified route map	Include information panels inside buses and at other touchpoints; highlight main stops and terminals with icons.
Multisensory (multimodal) redundancy	Install a discreet external loudspeaker emitting distinct tones by line when approaching stops; implement multimodal redundancy so information is accessible and perceptible through multiple senses.
Hierarchy and organization	Adopt a standardized layout: front/rear top band with number/line/pictorial info; side panels with destination and route.
Distance legibility	Dimension text and pictograms for long-distance reading; use high-brightness LEDs or reflective vinyls; ensure high contrast on all faces.
Compliance with standards	Align with Decree 5.296/04 and Law 12.587/12, including verification of contrast, typography, and multimodal redundancy.

This discussion is based on an exploratory sample and an expert/heuristic evaluation; it lacks usability testing with end users and temporal performance metrics (e.g., reading time at different viewing distances). Future research should: (a) quantify performance gains following typography/contrast interventions; (b) measure the effect of on-board audio on alighting errors; (c) assess alternative color-coding schemes with respect to color-vision deficiencies; and (d) investigate content-governance models suitable for local operational contexts.

6 Conclusion

The results reveal that the informational performance of São Luís's public transport system is most challenged at decision points under time and environmental pressure – boarding, in-vehicle travel, and alighting. These stages concentrate the highest cognitive load on users and demand efficient visual and auditory support for rapid decision-making.

Three heuristic dimensions – legibility (H4), accuracy/updating (H3), and multimodal redundancy (H10) – form a core cluster of failures that undermines the overall communicational efficiency of the system. Collectively, these weaknesses diminish passengers' informational autonomy, erode trust in the transport service, and contribute to behavioral compensations such as asking for verbal help, memorizing bus colors, or relying on informal knowledge networks.

These patterns are consistent with previous studies on wayfinding in high-demand urban environments, which emphasize the importance of perceptual clarity, stable information, and redundancy between visual and auditory channels to support quick spatial decisions (Arthur & Passini, 1992; Calori & Vanden-Eynden, 2015; Mayer, 2009). The findings also align with Universal Design principles, which advocate perceptible, redundant, and low-effort communication for users with diverse cognitive and sensory profiles (Connell et al., 1997; Story, Mueller, & Mace, 1998).

From a design perspective, the observed failures suggest that the current system prioritizes operational aspects (vehicle routing, scheduling) over informational quality and accessibility. However, as this study demonstrates, information design and governance are integral to the perception of service quality. Poor legibility and unreliable information not only hinder understanding but also compromise the user's perception of safety and efficiency – particularly for children, older adults, and low-literacy users, who depend more heavily on environmental cues.

To address these issues, three design priorities are proposed:

1. Legibility by distance: define minimum type sizes, contrast ratios, and exposure times based on empirical viewing-distance data, ensuring readability during movement and low visibility conditions.
2. Multimodal redundancy: integrate auditory and visual cues (icon–color–text–audio synchrony) for next-stop announcements and route identification, reducing dependency on a single sensory channel.
3. Information governance: implement continuous content management routines for maps, route lists, and terminals, including update cycles, responsible roles, and performance indicators.

These measures not only improve usability but also strengthen informational equity, ensuring that different user groups can interpret and act upon messages regardless of literacy level or sensory ability.

This research followed a heuristic evaluation framework, focusing on observable characteristics of communication artifacts rather than direct user testing. The purposive sampling – limited to 23 records – was designed to

identify recurrent patterns rather than to produce statistically generalizable results. The absence of direct user participation represents a deliberate methodological choice, justified by ethical considerations for non-intrusive public-space observation. Nevertheless, this choice limits the capacity to infer psychological or emotional responses (e.g., perceived stress, time pressure) that might complement the heuristic findings.

Future studies should therefore integrate user-centered methods, such as usability testing or eye-tracking experiments, to measure reading time, error rates, and comprehension under real travel conditions. Combining heuristic analysis with quantitative and participatory techniques would allow for a more comprehensive evaluation of communicational efficiency.

The study reinforces that access to clear and trustworthy information is an essential dimension of urban mobility. Informational accessibility is not merely a design concern but a social right that enables equitable participation in city life. By aligning principles of Information Design, Wayfinding, and Universal Design, the findings point toward a model of public communication that prioritizes clarity, reliability, and inclusion – key conditions for users to navigate, decide, and move through the city with autonomy and confidence.

References

Arthur, P., & Passini, R. (1992). *Wayfinding: People, signs, and architecture*. New York: McGraw-Hill.

Calori, C., & Vanden-Eynden, D. (2015). *Signage and wayfinding design: A complete guide to creating environmental graphic design systems* (2nd ed.). Hoboken, NJ: Wiley.

Connell, B. R., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff, E., Sanford, J., Steinfeld, E., Story, M., & Vanderheiden, G. (1997). *The principles of universal design* (version 2.0). Raleigh, NC: Center for Universal Design, North Carolina State University.

Garvey, P. M., Klena, M. J., Eie, W.-Y., Meeker, D., & Pietrucha, M. T. (2015). *The legibility of the Clearview Typeface System versus standard highway alphabets on negative- and positive-contrast signs*. University Park, PA: Pennsylvania Transportation Institute/U.S. Department of Transportation.

Instituto Brasileiro de Geografia e Estatística. (2023). *Pesquisa Nacional por Amostra de Domicílios Contínua – 2º trimestre de 2023*. Rio de Janeiro: IBGE.

Instituto Brasileiro de Geografia e Estatística. (2024). *São Luís: Panorama*. Rio de Janeiro: IBGE.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press.

Mijksenaar, P. (1997). *Visual function: An introduction to information design*. New York: Princeton Architectural Press.

Nielsen, J. (1994). Heuristic evaluation. In J. Nielsen & R. L. Mack (Eds.), *Usability inspection methods* (pp. 25–62). New York: John Wiley & Sons.

Pettersson, R. (2002). *Information design: An introduction*. Amsterdam/Philadelphia: John Benjamins Publishing.

São Luís (Município). (1996). *Lei Complementar nº 3.430, de 31 de janeiro de 1996*.

São Luís (Secretaria Municipal de Trânsito e Transportes). (2016). *Portaria nº 0245, de 13 de julho de 2016: Define o layout externo e a padronização das cores a serem empregadas nos ônibus*.

Story, M. F., Mueller, J. L., & Mace, R. L. (1998). *The universal design file: Designing for people of all ages and abilities*. Raleigh, NC: Center for Universal Design, North Carolina State University.

Tufte, E. R. (1990). *Envisioning information*. Cheshire, CT: Graphics Press.

W3C. (2018). *Web Content Accessibility Guidelines (WCAG) 2.1*. W3C Recommendation.

Wickens, C. D. (2008). Multiple resources and mental workload. *Human Factors*, *50*(3), 449–455. https://doi.org/10.1518/001872008X28839

About the authors

Bruno Serviliano Santos Farias
bruno.serviliano@ufma.br
Universidade Federal do Maranhão
São Luís, MA

Cristiano Frazão de Oliveira Silva
cristiano.frazao@discente.ufma.br
Universidade Federal do Maranhão
São Luís, MA

Submission date/*Artigo recebido em*: 5/9/2025
Approvement date/*Artigo aprovado em*: 28/11/2025