ANALYTICAL MODELS FOR SIGNAGE PLACEMENT IN AIRPORT INTERIOR SPACES BASED ON PASSENGER FLOW PATTERNS

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Rezumat. *Un sistem eficient de semnalistică în aeroporturi joacă un rol esențial în optimizarea fluxurilor de pasageri și crearea experienței de călătorie. Evoluţia traficului de pasageri impune ca aeroporturile să ofere fluxuri de circulaţie eficiente şi sigure. Articolul de faţă analizează modele de amplasare a panourilor de semnalistică în interiorul aeroporturilor pornind de la analizele realizate în cadrul proiectului de cercetare „Inovare, Cercetare și Construire fabrică de producție semnalistică” şi din literatura internaţională. Sunt prezentate metode de analiză a fluxurilor de pasageri, tipurile de semnalizare, criteriile de proiectare şi amplasare, corelaţia dintre fluxuri şi panouri, exemple de bune practici şi recomandări pentru integrarea în contextul românesc. Se evidenţiază importanţa reducerii numărului de viraje şi niveluri, a integrării semnalizării în arhitectura terminalului, a ierarhizării mesajelor şi a proiectării pentru toţi utilizatorii, inclusiv persoanele cu dizabilităţi.*

Abstract. *An efficient airport signage system plays an essential role in optimizing passenger flows and creating a travel experience. The evolution of passenger traffic requires airports to provide efficient and safe traffic flows. This article analyzes models for the placement of signage panels inside airports based on the analyses carried out within the research project "Innovation, Research and Construction of a Signage Production Factory" and international literature. Methods for analyzing passenger flows, types of signage, design and placement criteria, the correlation between flows and panels, examples of good practices and recommendations for integration into the Romanian context are presented. The importance of reducing the number of turns and levels, integrating signage into the terminal architecture, prioritizing messages and designing for all users, including people with disabilities, are highlighted.*

Keywords: Airport signage, passenger flows, natural orientation, service level, color coding

1. Introduction

As airports become multimodal transport hubs and complex commercial centers, guiding passengers through an efficient signage system is essential for safety and customer satisfaction. Reports [14] from Romanian authorities show that in October 2025, passenger traffic increased by 30% compared to the pre-pandemic

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period. The increase in volumes led to the expansion of airport infrastructure and the addition of terminals, which increased the complexity of travel. Designers must place passengers at the center of the planning process and aim for a natural and unobstructed flow through the terminal. Appropriate signage contributes to a good or very good level of service, reducing user stress and operational costs. An airport's signage and wayfinding system is essential in guiding travelers - from curbside and parking areas, through check-in and security, to departure gates and baggage claim - and in doing so, underpins both the passenger experience and the airport's operational efficiency. Globally, aviation organizations and standards bodies have established guidelines to ensure that airport signage meets certain safety and usability criteria. Together, these standards emphasize that signage should be clear, consistent, and intuitive, helping passengers of diverse nationalities, languages, and abilities navigate the airport environment. The International Civil Aviation Organization (ICAO) provides standard multilingual signs and symbols for airports in its Document 9636, "International Signage for Providing Guidance to Persons at Airports and Maritime Terminals" [15]. The International Air Transport Association (IATA) also emphasizes terminal wayfinding in its Airport Development Reference Manual (ADRM) [16], and regional authorities, such as the U.S. Federal Aviation Administration (FAA) [1], issue advisory circulars detailing best practices for airport signage and graphics. At the same time, airport operators and designers have developed innovative best practices and strategies to improve wayfinding. The purpose of this article is to present analysis models for the placement of signage panels in airport interior spaces, taking into account passenger flows. The research is based on the analyses carried out within the research project Innovation, Research and Construction of a Signage Production Plant, on international guidelines (ICAO, IATA, FAA, ACRP, PANYNJ), on European reports (LAirA, AFD) and on recent articles on digital signage, inclusive design and flow simulation. The structure of the article is as follows: passenger flow analysis, signage classification and design principles, correlation between flows and panel placement, international case studies, integration of panels in heavily trafficked spaces, inclusive design and accessibility, evacuation risks and security, conclusions and recommendations.

2. Passenger flow analysis

2.1. Traffic evolution and level of service

The increase in passenger traffic determines the need to optimize terminal spaces. The design of airport terminals must reflect the volume of passengers and baggage to be handled, and the level of service has long-term financial and operational implications. Different categories of passengers – travelers with hand luggage, families with strollers, business travelers – have different needs, which influences the dimensions of waiting and circulation areas. The level of service can be

considered as a range of values or as an assessment of the ability of the supply to meet demand. To allow comparison between different airport systems and subsystems and to reflect the dynamic nature of demand for a service, a range of service level measures from A to F can be used, similar to the standard used in road traffic engineering.

A - Excellent level of service. Free flow conditions, no delays and excellent levels of comfort.

B - High level of service. Stable flow conditions, very few delays and high levels of comfort.

C - Good level of service. Stable flow conditions, acceptable delays and good comfort levels.

D - Adequate level of service. Unstable flow conditions, acceptable delays for short periods of time, and adequate levels of comfort.

E - Inadequate level of service. Unstable flow conditions, unacceptable delays and inadequate levels of comfort.

F - Unacceptable level of service. Cross-flow conditions, system failures, and unacceptable delays; an unacceptable level of comfort.

Passengers prefer a minimum C level of service, but crowded aisles reduce the quality of service. Service level C is recommended as a minimum design objective because it denotes good service at a reasonable cost. Service level A is considered to have no upper limit. The total number of passengers in a designated queuing area tends to be fairly constant for any given flight. The space per occupant when the queue exceeds the limit is considered by IATA to be the boundary between service levels C and D. Passengers want to avoid experiencing a service level lower than C unless they are forced to do so. Passengers queuing in aisles that share space with passengers passing through them may, however, experience a lower level of service.

Appropriate information signage inside passenger areas at an airport contributes to achieving good and very good levels of service.

2.2. Traffic analysis models

FAA Advisory Circular 150/5360-12F recommends the development of circulation trees for each passenger type (departure, arrival, transfer) from the roadways and parking lots to the gate. These diagrams highlight space sequences, decision points, distances, checkpoints, and service areas [1]. It is recommended to use floor plans to track routes, identify intersections, and place signs where passengers need to make decisions. AC 150/5360-12F requires checking the visibility of signs in pedestrian flow, calculating the height of letters for legibility.

Another tool is flow simulation. A recent study published in 2024 proposes an artificial intelligence-based simulation system to manage terminal flows, optimizing waiting times and reducing congestion [8]. Simulation allows the identification of congestion areas and tests different panel locations without high physical costs [9], [13].

We emphasize the importance of prioritizing messages and identifying decision points: boards should be placed where passengers look for information – for example, immediately after disembarking from the plane to retrieve their luggage. In complex environments, exploded axonometric diagrams are recommended to understand multi-level flows.

2.3. Impact of terminal design

The physical design of the terminal influence's passenger perception and transfer delays. An article from Aalto University shows that multimodal terminal design can reduce or increase the perceived time and effort of passengers; well-designed terminals reduce transfer delays by shortening walking distances and waiting times [12]. Passenger orientation can be improved through transparency: the use of glass and unobstructed sight lines allow the passenger to see the aircraft and ground access systems. Avoiding intersections between flows and limiting turns to 90° contributes to fluidity of travel.

3. Classification and typology of signage

3.1. Panel categories

Signage in airport interior spaces is classified into three categories:

Directional signage is of the utmost importance in a terminal. All other categories are subordinate. Proper directional signs are necessary because the rapid movement of passengers is essential for maximum airport utilization. Directional signage provides arrows and messages that guide passengers to destinations such as ticketing, security, gates, baggage claim, and exits. Direction is especially vital for delayed passengers, passengers with disabilities, and foreign visitors.

Informative signage is considerably less important than directional signage, provides details about services and facilities and does not directly relate to the boarding process. These panels provide specific details about airport services and functions, such as: restaurants, toilets, telephones, snack bars, souvenir shops, newsstands, post office, operational offices, police etc. The purpose of these panels is to help people meet their needs that are not directly related to boarding aircraft, baggage retrieval, or exiting the airport.

Tertiary signage includes regulatory, advertising and identification signs. These have low priority and are intended to communicate regulations or promote.

Regulatory boards refer to the requirements and recommendations of the authorities for providing travel advice to passengers. Designated advertising display areas help communicate promotional information for various businesses inside/outside the airport, as well as establish a source of revenue for the airport. Identification boards provide businesses with appropriate public exposure in the leased space and other areas established by the airport authority.

Regarding the categories of use of the panels, we mention: signage for departures, arrivals, transfers, baggage and emergencies. Each category can have static or dynamic (digital) formats adapted to the context.

3.2. Design principles

An effective signage system must be designed and integrated from the early stages of terminal development. The basic principles are:

Standardized terminology and symbols – a language accessible to all, with recognizable symbols and uniform colors. Consistent terminology should be used in signage, maps, digital displays and verbal communication.

Message hierarchy – clear ordering of information: main messages (tickets, baggage, gates, ground transportation) and secondary messages (waiting rooms, restrooms, concessions). Signage should provide general information then specific details, with progressive disclosure.

Visibility and readability – the panels must be placed in the passenger's field of vision, with adequate lighting and without visual competition from advertisements. Readability is ensured by the size of the letters (12 m distance for each centimeter of height), chromatic contrast and anti-glare finishes.

Frequency and consistency – the number of signs should be kept to a minimum to reduce clutter, but sufficient to confirm the route on long corridors; confirmation signs should be placed every 45–76 m.

Mounting height – determined by the terminal architecture; viewing angles greater than 10° from the natural line are avoided. Orientation systems must be adapted to spaces with low ceilings or multiple levels.

Color coding – an effective tool for classifying destinations, but the number of colors should be limited and distinct.

Architectural integration – signage should be integrated into the building design, with obvious flow routes, memorable landmarks and consistent finishes.

3.3. Design principles

The types of orientation panels adapted to heavily trafficked spaces include the following types of panels:

Identification panels – door plates, departmental or monument signs; the design should be simple and precise.

Directional signs – guiding to destinations through arrows and color codes; these are essential in crowded areas, at intersections or in hallways.

Information boards – provide general information (toilets, opening hours, Wi-Fi, lifts) and should be placed in waiting rooms or at entrances.

Regulatory panels – convey warnings or rules (speed, prohibited access) and must have clear, visible symbols.

4. Correlating passenger flows with the placement of panels

4.1. Identifying decision points

A key step in planning signage is identifying the points where passengers need to make a choice. To simplify the process, the number of options should be kept to a minimum; ideally, a single terminal complex eliminates confusing alternatives. Orientation can be improved through transparency – passengers should be able to see their final destination or aircraft – and directional information is only needed for ancillary facilities located outside the main flow. Directional signage is placed before intersections and immediately after security checkpoints for confirmation. Additionally, wayfinding experts use the idea of decision points – mapping out where a passenger needs to choose a path (such as an intersection, a transfer train entrance, a ramp to another level) and ensuring that each decision point is clearly signposted. If there is no decision to make (a linear path), signs can be sparser, perhaps just confirmation signs, as needed.

4.2. Primary and secondary flows

Passenger flows can be classified into primary (from the entrance to check-in, security and gate) and secondary (towards toilets, restaurants, offices). Primary flow signs should be predominant, with large symbols and arrows, while secondary information can be provided in the immediate vicinity of the destinations. It is recommended that primary signs communicate destinations such as tickets/check-in, baggage claim, gates, ground transportation, and secondary signs target toilets or concessions. General flow diagrams should be developed showing passengers from origin, destination, transfer and transit, divided by all types of traffic (charter, scheduled), by sector (domestic, international, Schengen/Non-Schengen, etc.) and by short/medium and long routes. These are determined on the basis of statistical data and air traffic forecasts and should be prepared for existing and projected traffic covering years 0, 5, 10 and 20 of the forecast period.

Airport terminals should be designed with the natural flow of pedestrians in mind, and signage should reinforce this flow rather than counteract it. One principle is continuity of message: if a sign directs a passenger to "Gates A1–A10" at a particular location, subsequent signs should continue to refer to those gates until the passenger reaches their destination. Abruptly ceasing to mention "A1–A10" before the passenger reaches the gates would break continuity. Another is to avoid sending mixed signals—for example, a sign that says "All Departures →" and immediately next to it another that says "Exit ↑" could confuse someone in a hurry, as they might confuse the arrows.

Passengers should not be subjected to changes of direction greater than 90 degrees and should not be required to make repeated 90-degree turns over a short distance. Under no circumstances should passengers be required to turn around or walk in the opposite direction to the flow of passengers.

Situations where passenger flow routes intersect should be avoided, as this will cause confusion and, in cases where passenger transfers for people with disabilities or assisted vehicles are also present, may also be dangerous.

If possible, departing and arriving passengers should not be required to change levels. If changes are necessary, they should be limited to a single level.

4.3. Frequency and arrangement

In theory, the fewer signs, the better; however, complex spaces may require additional signs. The goal is consistency of frequency: passengers expect to encounter periodic confirmations, especially in long corridors. Confirmation panels are placed 45–76 m along airport corridors, and the mounting height depends on architectural conditions. Linear orientation, based on visual access to the destination, reduces reliance on panels and the number of signs required. Signs are generally placed a few seconds before a decision is required, allowing people to slow down and check the directions without causing sudden stops. Another placement consideration is line of sight: signs should not be blocked by architectural features or low ceilings. The trend in international practice is to mount important directional signs as high as possible (often from the ceiling or on tall poles) so that they can be seen above a crowd of people and from afar.

4.4. Conceptual model

Fig. 1 shows a conceptual diagram of an interior terminal and the main passenger flows. Primary routes are marked with thick arrows and secondary routes with thin arrows. Directional signs are placed at intersections and near decision areas such as entrance, security, transfer and gates.

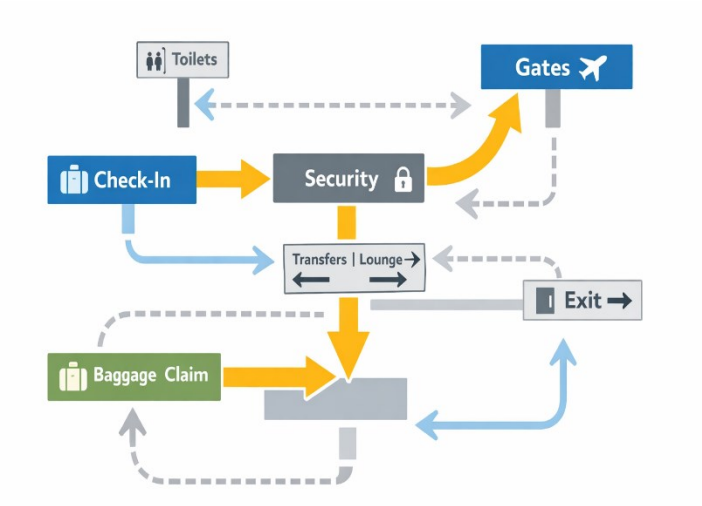

Fig. 1. Example of a conceptual diagram for primary flows, secondary flows and panel placement.

One of the most important aspects of good signage is placement. The closer to the natural line of sight, the better. A useful rule of thumb is to avoid exceeding a 10° angle from the natural line of sight. If conditions require the viewing angle to exceed 10°, the relationship between size and distance may need adjustment.

5. International case studies

5.1. PANYNJ (Port Authority of New York & New Jersey) standards

Following the synthesis of the PANYNJ standards on orientation, we concluded on three guiding principles for the design of signs according to passenger flows: “bright basic elements”, “less is more” and “exceeding expectations”. The basic elements require that information be clear, comprehensive and visible. The principle of “less is more” requires the avoidance of visual clutter and the integration of signs into the architecture. The third pillar emphasizes the creation of relaxing moments for passengers, so that they are not stressed by orientation. The principles encapsulate a modern approach to airport signage: provide essential information clearly (bright basics), avoid information overload (simplify and eliminate clutter), and go beyond the bare minimum to make navigation comfortable and even enjoyable for travelers. State-of-the-art airports incorporate natural wayfinding cues - architectural features, lighting, and unique landmarks - to complement signage, thereby reducing reliance on signs by intuitively guiding passengers along logical routes.

The standards promote natural orientation: architecture should guide through form, light and memorable landmarks (e.g. the monumental Daxing Skyscraper in Beijing, or the luminous atrium at Heathrow). Spatial zoning separates orientation areas from commercial media; similar information is placed in predictable

locations above the flow. This zoning keeps signage in the optimal field of vision and prevents competition with commercial media. Colour-coded information areas, as seen at airports such as Amsterdam Schiphol and London Gatwick, ensure that similar information is grouped and easily distinguished, preventing signage from competing with visual elements in retail or advertising. Consistent placement of similar information in predictable locations helps to understand the airport environment, allowing users to more easily perceive the space and find information. At Amsterdam Schiphol Airport, the orientation area is placed directly above the flow area. This keeps orientation always in the passengers' optimal field of vision and free of visual distractions, as seen in Fig. 2. At Singapore Changi Airport, the orientation area is clearly separated from the commercial displays by a buffer zone. A designated space for each type of display reduces competition and allows passengers to read both types of displays, as seen in Fig. 2.

Fig. 2. Orientation area and flow area – Amsterdam Schiphol Airport and orientation area – commercial supports – Singapore Changi Airport, images from Port Authority Wayfinding Manual, Port Authority of NY & NJ [3]

The principles are complemented by an inclusive design that takes into account the needs of all users, including people with disabilities. The information strategy follows a "general to specific" approach, progressive disclosure and color-coding.

The objectives of spatial zoning: a) Allocating the most efficient location for different types of information and media; b) Ensuring that the location of information is expected and predictable; c) Creating clear visual lines on the main path and on orientation elements; d) Ensuring that all media enhances the overall airport experience; e) Guaranteeing visibility by preventing interference between different types of media.

The following image (Fig. 3) presents a functional zoning model for interior terminal spaces, illustrating the spatial relationship between pedestrian flow areas, wayfinding zones, and media placement. The model highlights how circulation, orientation, and buffer zones are organized to support efficient passenger movement and clear information delivery.

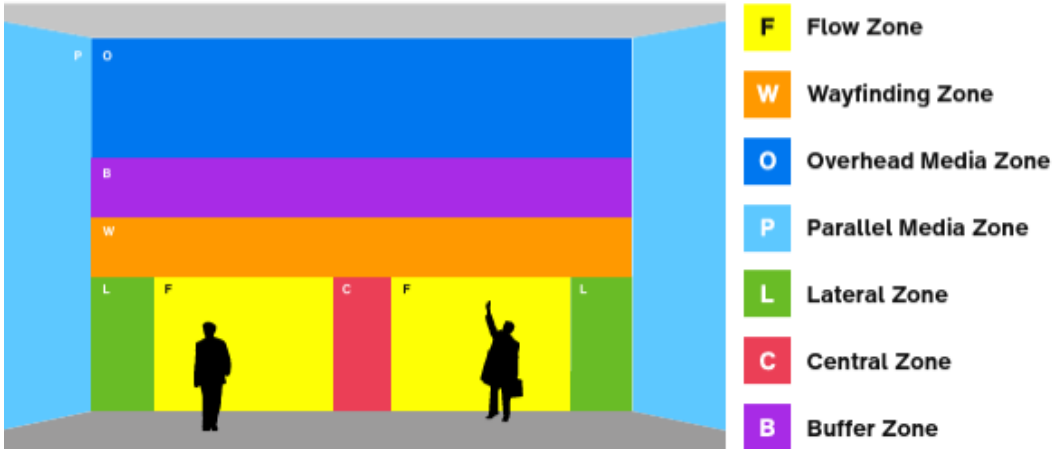

Fig. 3. Spatial Zoning in airport, Port Authority Wayfinding Manual Port Authority of NY & NJ [3], [4].

5.2. FAA and ACRP Guide

ACRP Report 52 emphasizes the importance of the 3Cs – continuity, consistency, and connectivity. Continuity ensures fluidity of movement in a diverse architectural environment; connectivity provides the right message at the right time; and consistency maintains stylistic and terminological unity [2]. The report shows that the Philadelphia International Airport wayfinding system overhaul program included enlarging the lettering, revising the placement of signs, and improving lighting [2].

FAA Advisory Circular 150/5360-12F provides detailed guidance for the design and placement of signs. Circulation trees, route analysis for each type of passenger, identification of decision points, and calculation of font size are essential elements [1]. The document emphasizes the need to verify visibility, comply with ADA requirements (tactile, Braille, contrast), and delineate clear areas around signs.

5.3. Multimodal Transport Hubs – AFD

The AFD Guide for Multimodal Hubs recommends inventorying and locating all information sources (desks, displays, panels), assessing the quality of the information and ensuring readability for people with disabilities [5]. Information must be reliable, prioritized and standardized across the platform. The report emphasizes that a coordination plan (blueprint) avoids redundancies that can disorient passengers.

5.4. LAirA – Wayfinding at Airports

The European LAirA report highlights that physical signage is essential in airports, as passengers cannot “move the airport” and depend on directions to

navigate. The use of text, icons and colours must be designed for international users with different languages and cultures. The report draws attention to the absence of a global symbol standard and recommends the adoption of intuitive and tested iconographies.

5.5. Digital signaling systems

Recent articles highlight the role of digital signage in airports. A 2025 Nento report shows that digital signage reduces missed flights, provides real-time information, and enables centralized content updates [11]. Digital signage can include interactive maps, flight information, security alerts, and routing messages. MappedIn (2024) shows that a centralized digital system simplifies navigation, optimizes operations and provides analytics on passenger behavior [6], [7]. Integration with mobile apps and beacons allows passengers to receive personalized notifications.

6. Integration of panels in heavily trafficked interior spaces

Signage can be integrated into shopping malls, hospitals and other crowded spaces. The main benefits of signage are creating a safe environment, familiarizing visitors, easy brand identification and reducing congestion. Signage should be easy to see and provide quick directions. Directional signage is essential in high-traffic areas; consistent colors and symbols allow passengers to find their way. Information signs address basic needs and should be placed in waiting rooms and hallways. Regulatory signs set boundaries and rules and should be visible even to those who do not know the local language.

6.1. Inclusive design and accessibility

Inclusive design involves considering the needs of all users. Airports are becoming larger and more complex, and information needs to be provided in multiple formats to accommodate a range of abilities. The Blink Signs Guide notes that simple pictograms, high contrast, and short messages support both people with disabilities and the general public, creating a “cognitive ramp effect [10].

Regarding the needs of visually impaired people, it is worth noting that an ineffective signage system can alienate them and cause delays, lost flights and increased costs. Signs should also be designed for staff, crews, suppliers and visitors who do not know the airport or the language. The information strategy should be holistic, anticipating needs at every stage of the journey and using progressive disclosure.

6.2. Evacuation and security risks

In terms of risk assessment for evacuation and flows, it should be noted that obstruction of escape routes is prohibited; placing signs, bicycles or furniture in corridors reduces the width of passage and delays evacuation. To ensure security, passenger and baggage routes must be simple and obvious, and domestic and international flows must be separated. Directional signs must not constitute obstacles on escape routes and must be mounted in such a way as not to affect free movement. The number of security checkpoints must be reduced by centralization, and access to restricted areas must be controlled.

7. Recommendations

Implement a flow analysis-based orientation plan - Airports should map departure, arrival, and transfer routes for different types of passengers, identifying decision points and congestion areas. Based on this analysis, signage is sized and placed at appropriate distances and heights.

Adoption of international standards with local adaptations - It is recommended to use international terminology and symbols from ICAO/IATA and harmonize colors, but with adaptation to the Romanian language and cultural context. Consistency of signage on all channels (static panels, maps, mobile applications) is essential.

Integrate digital technology - Digital signage should provide real-time information about flights, gate changes and waiting times, complementing static signage. It is recommended to use data analytics (heat maps) to adjust the positioning of the signage based on passenger behavior.

Inclusive Design - All signs should be designed to meet accessibility requirements: tactile characters, Braille, high contrast, tested pictograms, and mounting at accessible heights. Additionally, testing with diverse user groups is recommended before implementation.

Integration with security and evacuation plans - Signage should be coordinated with evacuation routes and security plans to avoid obstructing flows. It is recommended to centralize checkpoints and avoid areas where signs could create obstacles.

Conclusions

The article presents an integrated methodology for the placement of signage according to passenger flows in airport terminals, starting from the activities carried out within the research project on signage and complementing them with international guidelines and recent literature. In relation to previously published works, the following scientific contributions can be distinguished:

Combining Traffic Analysis with Signage Design - While ACRP and FAA detail the general principles of wayfinding systems (3Cs – continuity, consistency, connectivity) and requirements for visibility, legibility, and installation, this paper combines these rules with concrete flow analysis models (circulation trees, AI simulation) to determine where decision points and congestion occur. This direct correlation between actual passenger routes and sign placement is less present in the specialized literature.

Unitary methodology adapted to Romanian airports - The included analyses address the specifics of infrastructure and traffic in Romania, where passenger traffic has increased significantly in 2025. The paper proposes a hierarchy of messages (main, secondary and tertiary messages), recommends positioning panels at optimal distances and heights and applies color coding according to local flows. This contextual adaptation is not present in international guides, which are general in nature.

Inclusive Design and Accessibility - While many studies only mention accessibility as a legal obligation, the paper highlights the direct impact of inclusive design on all travelers, featuring intuitive pictograms, high chromatic contrast, tactile panels and Braille. It shows that a design for users with limited mobility, vision or language skills generates a "cognitive ramp" effect that facilitates orientation for all passengers.

Security and evacuation dimension - Unlike most works that treat signage only as a guidance tool, the article includes an analysis of the risks related to evacuation and security. It is shown that signs should not obstruct escape routes, and passenger and baggage flows should be separated and simplified. This correlation between signage and evacuation plans is rarely addressed in the current literature.

Abbreviations

ICAO - International Civil Aviation Organization.
IATA - International Air Transport Association.
ADRM - Airport Development Reference Manual.
FAA - Federal Aviation Administration.
ACRP - Airport Cooperative Research Program.
PANYNJ - Port Authority New York and New Jersey Airports and Flights.
LairA - Landside Airports Accessibility.
AFD - Agence française de développement.

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