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Continuous transport systems in public passenger transport

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ABSTRACT

In densely populated urban areas, there is an ongoing effort to curtail car usage and to promote innovative modes of transport. This paper presents a study of subsystems for specialised passenger transport, including escalators and moving walkways, and their respective characteristics and operating technologies. A global perspective reveals that the integration of escalators and moving walkways has led to substantial enhancements in the efficiency and passenger experience in airports, railways, and metro stations. A comparative analysis reveals that accelerating moving walkways offer distinct advantages over traditional public transport systems, including reduced waiting times, enhanced accuracy, increased comfort and a more appealing user experience. However, they are characterised by low speed, low spatial flexibility and lack of protection from atmospheric precipitation.

1. Introduction

The primary factors driving the transition towards private vehicle usage in densely populated urban centres are pollution, congestion and urban considerations. Urban environments require safe, fast and energy-efficient public transport to ensure sustainable living conditions. However, many cities do not have sufficient space or resources to provide robust public transport systems, such as metro systems [1].
Public transport should be the key integrator in the development of mobile systems, as it enables the efficient connection of different modes of transport into a coherent and functional system.

There are different forms of public transport, such as:

- Public mass passenger transport system consisting of: bus subsystem, tram subsystem, trolley subsystem, metro subsystem, light rail transport subsystem, suburban rail subsystem.
- Flexible passenger transport system consisting of: public bike, car-sharing, car-pooling, taxi, jitneys, demand responsive transport.
- A specialised passenger transport system consisting of: escalators, moving walkways, cable car, funicular, lifts, micromobility.

Escalators and moving walkways play a vital role in public transport systems and are often key elements in facilitating passenger movement. The sizing of access elements at stations and stops in large transfer points is important for ease of use, comfort and therefore the quality of service that the public transport system provides to passengers. By continuously moving people, escalators and moving walkways provide easy passenger flow, have a large transport capacity and, together with lifts and automatic doors, provide a complete solution for the rapid flow of people and goods in public transport systems [2].

The concept of moving walkways, otherwise referred to as pedestrian conveyors, was developed as a system to facilitate the movement of pedestrians on designated routes, or alternatively, as the primary mode of transport within urban centres. This concept has been present in the history of transport since the late 19th century. Indeed, the use of extremely rapid (speeding at over 100 km/h) and substantial moving walkways as the principal mode of transportation within a future megalopolis has been depicted in numerous science fiction novels [3].

This paper presents the characteristics of specialised means of public passenger transport (escalators and moving walkways). A comparative analysis shows the advantages and disadvantages of using accelerating moving walkways in comparison with traditional public transport systems.

2. Escalators and moving walkways

Escalators and moving walkways are among the most widely used and convenient means of accessing public transport systems. Each of these access systems has its own advantages, as shown in Table 1.

Table 1. Main transport characteristics of escalators and moving walkways

Escalators	Moving walkways
Continuous transport	Continuous transport
Mass transport	Mass transport
Short/medium distances	Short/long distances
Between levels/floors	On level
Managing the flow of people	Save time and effort

2.1. Operating technology

An escalator is a transportation device consisting of a single chain of aluminium or stainless steel, driven by a motor, with steps that move along a system of rails arranged in a continuous loop. These access systems are often used in buildings with a large number of visitors and a high flow of people, such as metro stations, airports, etc. Some types of escalators can be installed outdoors and protected from bad weather. The most common types of escalators are: step, spiral, levitating and wheelchair-accessible [4].

The most common type of escalator today is the step escalator which help people to go between different floors more quickly and easily. The steps are moved by a pair of chains looped around another pair of sprockets. This system rotates around a larger metal piece called a bracket, which keeps the whole mechanism connected to the floors. Spiral escalators have curved steps which give them a very unique appearance. They have been manufactured exclusively by Mitsubishi since 1985 and there are only 91 of them in the world. The largest spiral escalator was built in Shanghai [5]. A levitator is a free type of escalator that can be curved multiple times, both up and down. With two escalators sharing the stair loops, the levitator can curve in different ways. As the levitator moves up and down without using two separate motors, this system saves on energy consumption [6]. A wheelchair-accessible escalator is similar to a standard step-type escalator, but is used with special adaptations. When used by a wheelchair user, it is put into a special mode in which the three steps move and flatten to form a platform. Spikes then protrude from the back of the steps, closer to the lower level, to prevent the wheelchair from falling.

Moving walkways are used for the horizontal and continuous transport of people on a level surface. They are mainly installed in places where people have to travel long distances with luggage. Moving walkways use a series of interconnected metal pallets mounted on rollers. The pallets mounted in this way form a chain in a loop, with the upper exposed part providing a standing surface for users. When the loop reaches the end of the treadmill, the pallets are turned and returned to the service area, which is concealed directly under the exposed top section [7].

2.2. Technical characteristics

Escalators or moving walkways is a complex combination of components and technical features. Many of these features, such as width, length, speed, slope and capacity, are available in different specifications. The width of escalators can be 600mm, 800mm and 1000mm. The width of stairs in public transport systems is usually 1000mm and allows comfortable movement of passengers together with their luggage [4]. The widths of horizontal moving walkways range from 1000mm, 1200mm and 1400mm for non-slope moving walkways and 1000mm and 1100mm for slightly slope moving walkways, and less commonly 800mm. In airports, there is an increasing tendency to use moving walkways with a width of 1200mm or 1400 mm. The 1400mm belt width allows two adult passengers to stand on one pallet, maximising the capacity, while the 1000mm/1200mm pallet width allows one adult passenger and a small child to stand on one pallet, or one adult passenger with luggage [2].

The minimum length of the moving walkways is 10m, and the maximum length is 250m, with the fact that in practice, in public transport systems, the length of the moving walkways is usually 100m, and less often 200m, with the practice that the width of the moving walkways for lengths greater than 200m is 1600mm, solely for the better comfort and safety of passengers [8]. These types of lanes are most often installed in airports between terminals, metro stations and other public transport systems with high passenger flows.

Standard transport escalator speeds are 0.5m/s, 0.65m/s and 0.75m/s. Moving walkways speeds can be 0.5m/s and 0.65 m/s. A standard speed of 0.5m/s is used for short distances, but moving walkways usually run at 0.65m/s, providing a good balance between passenger capacity, comfort and energy efficiency [2]. Escalators are normally designed with a slope of 27.3°, 30° and 35°. The most common slope is 30°, but it can be increased to 35° if the vertical distance does not exceed 6m and the speed is limited to 0.5m/s. In cases where the height exceeds 6m, slope of 27.3° is ideal, although it requires more space in terms of length [4].

3. Accelerating moving walkways

Accelerating moving walkways (AMW) are divided into three sections: acceleration, constant speed and deceleration. The acceleration section has an acceleration between $0.14m/s^2$ and $0.43m/s^2$, depending on the installation [9]. In this section the speed increases from an entry speed of between 2.1km/h and 2.7km/h to the maximum speed [10]. Real AMW implementations show that the maximum speed can be up to 12km/h. The constant speed section has zero acceleration and the passengers can walk, so the walking speed is added to the maximum speed of the AMW. The walking speed depends on factors such as the age, gender and purpose of travel of the individuals, and is averaged at the walking speed of standard moving walkways, which is 3.7km/h on average. The final section is the deceleration section. Here the speed is reduced to an exit speed equal to the entry speed for a safe landing [11]. The AMW has a constant width over its entire length. The typical width of the passenger compartment is between 0.8m and 1.6m, and the width of the aisle is between 1.2m and 2.3m, taking into account the necessary side installation. AMW are fully electric and therefore reduce local greenhouse gas emissions. In addition, the system has a low noise level of approximately 54dB [12]. Compared to other urban transport modes such as buses and light rail systems, AMW have competitive speed, operating costs and capacity, with the advantage of limited corridor width. However, they have higher capital costs, especially compared to buses. Buses and light rail have higher maximum speeds, but the discontinuous nature of these systems reduces the average speed.

Buses have an average speed of between 15 and 20km/h, while light rail can reach speeds of up to 45km/h. AMW can have a maximum speed of up to 15-17km/h, as pedestrians can walk along the route at a constant speed. This speed is competitive with private cars travelling at an average of 15km/h during peak hours [13]. AMW are designed for high traffic demands and have a maximum capacity higher than buses, which range from 1,000 to 9,600 passengers per hour, but lower than light rail, which can serve to 30,000 passengers per hour. AMW also take up less space than other modes of transport. This is an advantage when integrating the system into the urban environment. Buses and light rail have corridors between 2.5m and 4.2m wide in each direction, more than twice the minimum width of these continuous systems. Noise levels are also lower than other modes, ranging from 60dB to 84dB [14].

4. Comparative analysis of AMW and tradicional public transport systems

A comparative analysis of public transport and the AMW shows differences in key parameters. The basic differences between these characteristics are shown in Table 2.

Table 2. Comparing features of AMW and tradicional public transport systems

Criterion	Bus system	LRT (light rail system)	AMW
Waiting time at the bus stop	long	short	without waiting
Accuracy	average to poor	good to average	great
Driving speed (km/h)	15 – 20	15 - 45	max 15 - 17
Spatial flexibility	high	low	not flexible
Capacity (passenger/h)	1000 - 9600	1000 - 30000	4500 - 8000
Comfort	average to poor	good to average	very good
Protection from atmospheric precipitation	protected	protected	not protected
Attractiveness	average	average	high

Waiting times for traditional public transportation can vary depending on schedule and frequency. Passengers often have to change their travel plans, whereas AMW provides a no-wait system because the moving walkways are in constant motion and passengers can quickly board and begin their journey at any time. AMW systems offer greater accuracy than traditional public transport, which is subject to many factors, including traffic congestion and delays, so passengers can often experience variations in arrival times. Speed is another parameter where AMW systems outperform traditional public transport, as passengers move quickly from point A to point B. On the other hand, until AMW systems are implemented in the road network, traditional public bus transport offers greater spatial flexibility, as it includes a wide range of routes and stops. Passengers have multiple options for travelling to their destination, which can be particularly useful for those with multiple destinations within the city. In terms of convenience and attractiveness, AMW systems are often rated highly for their speed and convenience.

The capacity of the AMW system often depends on the specific design, length and number of belts installed. Under optimal conditions, this system can provide fast and efficient transport for a large number of passengers in a short period of time. However, the capacity of the AMW is not infinite and careful planning is required to meet the needs of the passengers, especially in cities with dense traffic and high demand. Weather protection is also an important feature of these systems. When AMW are installed outdoors, they are exposed to changing weather conditions such as rain, snow, wind and high temperatures. In this context, their design requires adequate protection measures to ensure smooth operation in different weather conditions.

This includes quality materials that are resistant to corrosion and damage, as well as a monitoring and maintenance system to respond quickly to any problems caused by weather factors.

5. Conclusion

Continuous access systems have become an indispensable part of public transport systems. They contribute significantly to the mobility of citizens, making travel faster and more efficient. They also provide greater accessibility for people with reduced mobility.

To successfully plan and implement a system of accelerated lanes, it is important to take into account the needs and demands of citizens. This includes analysing their habits and expected benefits. The volume and efficiency of AMW usage have a direct impact on users and the urban environment. A high level of use means that they are successful and meeting the needs of users. In addition, the volume of use can mean a great saving of time and energy for users in their daily journeys. On the other hand, the efficiency of AMW refers to how well they help traffic flow and reduce congestion. If they are effective, this means that they can significantly reduce traffic and congestion problems in urban areas. Compared to traditional public transport systems, the accelerating moving walkways system is a system without waiting, since the moving walkways move continuously, and this system is characterised by greater precision, comfort and attractiveness. On the other hand, less spatial flexibility and lack of protection from atmospheric precipitation are its negative sides.

The final choice between public transport and the AMW system depends on the specific needs and characteristics of a given city or region. Both approaches have their strengths and limitations, and can often be complemented to create a comprehensive and efficient public transport system.

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