**Review of Design and Functional Solutions for Platform Sliding Doors in the Metro of Large Cities around the World**

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**Abstract.** Platform doors (PSD) are an important element of modern metro systems, increasing safety, comfort, and energy efficiency. The article analyzes the design solutions of PSD: full-height (FH-PSD), half-height (APG), and closed-type systems ("horizontal lift"), first used in the Leningrad metro in 1961. The paper considers backgrounds (tempered glass, stainless steel), synchronization mechanisms (beam sensors), automation, and modification for passengers with limited mobility. Using the examples of the subways of St. Petersburg, Istanbul, Beijing, Tokyo, and Singapore, it is shown how PSD reduces accidents, optimizes energy consumption and manages passenger flow. In cities with extreme temperatures like Tashkent, climate control is a major priority. Thanks to the FH-PSD system, ventilation costs at subway stations can be reduced by up to USD 58 million per year per station. The study explores the pros and cons of various platform screen door (PSD) technologies and discusses the exciting potential of combining them with IoT and AI to create smart, energy-efficient systems. Overall, PSDs are becoming the standard for new metro lines, playing a key role in promoting sustainable urban mobility. The article is addressed to transport engineers, urbanists, and subway researchers.

## Keywords: platform sliding doors, full-height platform doors, half-height platform doors, automatic platform gates, subway

## INTRODUCTION

Platform sliding doors are a security system installed at metro stations to prevent unauthorized access to railway tracks, as well as to restrict access to tunnels, which eliminates the possibility of people falling on the tracks and reduces the risk of accidents.

The first platform sliding doors appeared in St. Petersburg at the Park Pobedy station on April 29, 1961. The platform sliding door system consists of a barrier in the form of a wall with sliding doors, most often made of glass, reaching the ceiling and completely isolating the station from the tracks. The introduction of platform doors in the metros of large cities around the world is due to a number of factors reflecting their importance for modern transport systems. With the growth of passenger traffic in megacities such as Beijing, Tokyo, Tashkent, London, and Moscow, metros carry millions of passengers daily. The high density of human flow increases the risks associated with safety, which makes PSD a necessary solution for preventing accidents [7].

**Design Solutions for Platform Doors**

There are several main types of station doors in the world, which can be divided into three main categories according to their functionality and design: Full-Height Platform Doors (Full-Height PSD) Figure 1. Full-height doors completely separate the platform from the tracks, creating a barrier from the floor to the ceiling. They provide maximum safety, preventing not only passengers from falling but also foreign objects from getting onto the tracks. Such doors can be supplied in a sealed version. This allows you to effectively ensure passenger comfort and minimize the costs of maintaining the microclimate at stations - hot air from trains does not get onto the platform and there is no need for additional fees for air conditioning, or, conversely, in case of low temperatures, the platform is protected from them and there is no need to use powerful thermal curtains.

The advantages of full-height platform doors include a high degree of safety, maintaining a comfortable microclimate (at closed stations), effective sound insulation, and preventing pollution of the tracks.

The disadvantages of full-height platform doors include significant installation and operating costs, as well as difficulties with implementation in outdated stations.



**FIGURE 1.** Full-Height Platform Doors (Full-Height PSD)

Platform sliding doors (HH-PSD) are installed security systems at subway stations and also separate the platform from the tracks (Fig. 2). Unlike full-height doors (FH-PSD), HH-PSDs are usually waist-to-top height (approximately 1.2–1.8 m) and do not reach the ceiling. Such developments are used at stations where full isolation is impossible or impractical, such as open platforms or stations with architectural restrictions. Below, we study the design features of these doors, as well as their advantages and disadvantages, and, moreover, the practice of using them in large city subways. Platform sliding doors, which are distinguished by their cost-effectiveness and ease of installation, are an ideal solution for upgrading stations and subway lines with low passenger flow rates. However, limited insulation capacity, reduced noise, and climate protection limit their use in highly automated transport systems and areas with extreme climatic conditions. Financial resources, architectural characteristics of the station, and operational parameters, determine the use of HH-PSD, which makes them a significant element in the world practice of implementing platform fencing.

The advantages of these doors are reduced capital costs and simplified integration with the existing infrastructure.There are also disadvantages, such as insufficient protection from climatic and acoustic impacts, and a limited ability to prevent foreign objects from entering the track.



**FIGURE 2**. Half-Height Platform Doors

**Automatic Platform Gates (APG)**

Automatic platform screen doors, identified as HH-PSD (Half-Height Platform Screen Doors), are systems for partial isolation of platforms from the tracks, with a height ranging from 1.2 to 1.8 m. They are equipped with automatic sliding doors synchronized with the opening of the doors of the rolling stock. APGs have become widespread in megacities such as Tokyo, London, and Seoul, due to their high adaptability and cost-effectiveness. These systems are relevant at stations with architectural restrictions, open platforms, or on lines with moderate traffic, where the installation of full-height doors (FH-PSD) is impractical.

The advantages of APGs include compact design, high speed of installation, and adaptation. The disadvantages of APG gates are a reduced level of protection compared to full-height barrier systems.

**MATERIALS AND DESIGN**

Platform door systems, be they full-height, half-height, or APG, are critical elements of transport infrastructure. Design solutions and materials used directly affect safety, operational reliability, visual perception, and technological efficiency. The most common materials in the production of platform fences are tempered glass, polycarbonate, and aluminum alloys. Glass panels provide transparency and modern design, while aluminum components are responsible for strength and lightness. Automatic sliding mechanisms operate on electric drives or pneumatic systems, and built-in sensors minimize the risk of passenger entrapment.



**FIGURE 3**. The door design includes automatic sliding mechanisms



**FIGURE 4.** Infrared beams under the train body

Signaling systems are used to synchronize the opening and closing of doors. For example, the St. Petersburg metro uses photocells. When a train stops at a station and the doors open, the lights on it light up. The light from them falls on the equipment with photocells, after which the station doors open. There are also such as in other countries CBTC (Communication-Based Train Control), which ensures precise positioning of the train relative to the platform.

**FUNCTIONAL SOLUTIONS**

In St. Petersburg, at the stations of the "horizontal lift" (for example, "Park Pobedy", and "Moskovskaya"), infrared beams are used under the train body to determine the position of the car with an accuracy of ±45 cm. At stations with FH-PSD, such as "Zenit", photo sensors and automatic train control systems (ATO) are used.

In the Singapore example, all metro stations are implemented with an automatic train control system (ATO), which provides a synchronization accuracy of ±10 cm.

And in the Istanbul example, on the M5 line (Uskudar-Cekmekoy), the automatic train control system (FH-PSD) uses radar sensors for driverless trains.

Supply and exhaust ventilation with heat recovery makes it possible to reuse up to 30% of thermal energy, reducing energy consumption. Automated air conditioning systems control air parameters depending on the station occupancy and external conditions. Intelligent sensors (CO₂, temperature, humidity) provide precise climate control in real time.

Platform-shaped doors help to regulate the flow of passengers, preventing overcrowding on platforms. For example, in the Beijing subway, the doors are equipped with indicators that show where the train doors are, which improves boarding.

Modern automatic train control systems (PSD) are integrated with automated train operation systems (ATO). This is especially important for fully automated lines such as Line 14 in Paris or the Circle Line in Singapore, where the accuracy of train stops reaches a few centimeters.

**FINANCIAL EFFICIENCY OF FH-PSD IN TASHKENT METRO**

Integral indicators enable the assessment of the project's financial efficiency, its viability in external and internal conditions, and the factors specified by the calculation model. Positive parameters of integral indicators in comparison with the efficiency of investments in alternative projects allow to development of a management decision on the implementation of the project and/or restrictions on its implementation.

Large infrastructure projects implemented by the state and/or quasi-state entities, and not having sufficient indicators of financial efficiency, must have direct economic efficiency and/or multiplicative economic effects.

a) Payback period

The payback period is the time required to cover the initial investment due to the net cash flow generated by the investment project.

b) Discounted payback period. The discounted payback period is calculated similarly to the simple payback period, but when summing up the net cash flow, it is discounted.

c) Average rate of return. The average rate of return represents the profitability of the project as the ratio between the average annual revenues from its implementation and the amount of initial investment.

d) Net present value

Calculation of the indicator:

NPV = (∑CFt / (1+r)t-1) – “Investments”

where “Investments” - initial investment

CFt - net cash flow of month t; r - monthly discount rate.

Its value is absolute and indicates what amount of net income we will receive from the implementation of the project relative to possible alternative investments.

d) Profitability index

Calculation of the indicator:

PI=∑CFt/(1+r)t-1/Investment

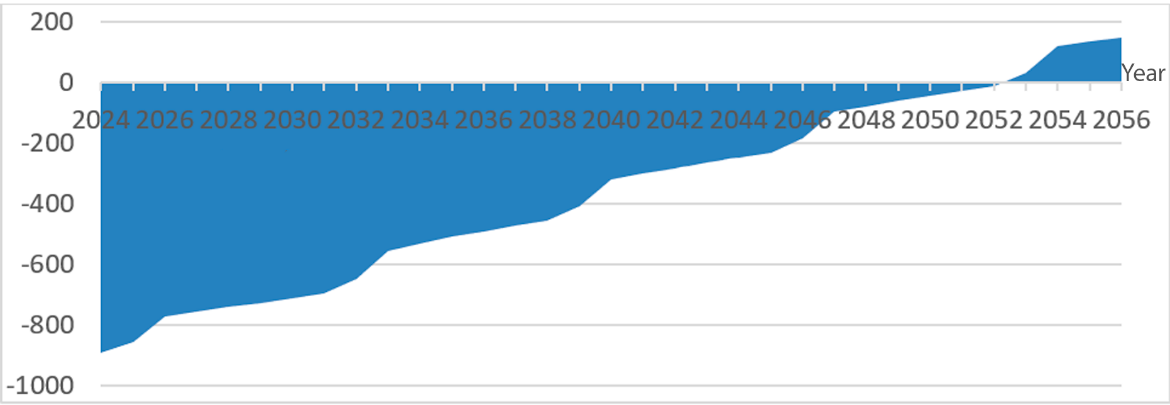
where Investments - initial investment; CFt - net cash flow of month t; r - monthly discount rate.

The project is considered acceptable if PI is greater than 1.

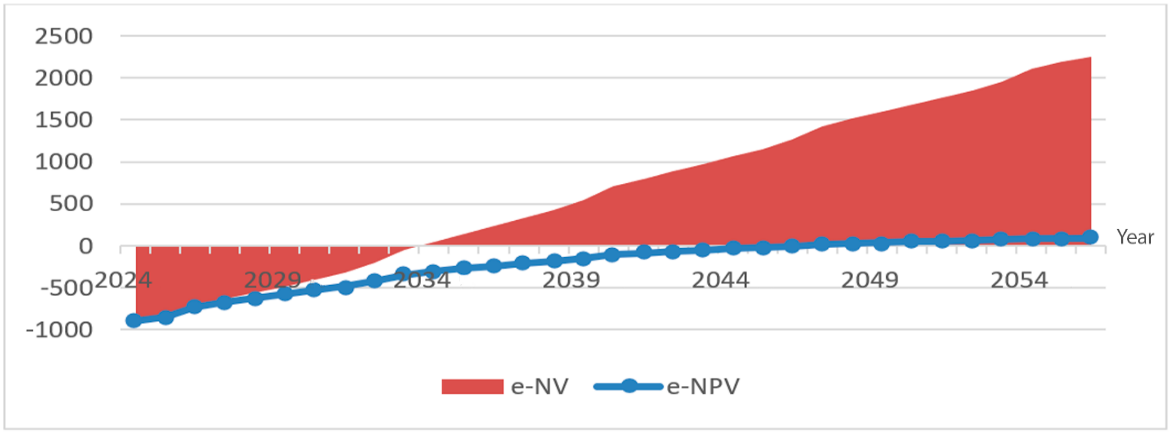
e) Internal rate of return

The project is considered acceptable if the calculated IRR value is not lower than the required rate of return. The value of the required rate of return is determined by the investment policy of the enterprise.

**Energy efficiency of FH-PSD in Tashkent metro: brief calculation**

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**FIGURE 5.** Payback graph by net income without discounting, billion soums

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**FIGURE 6.** Payback graph by set of socio-economic effects at a discount rate of 6%, billion soums   
(Net income - e-NV, Net present value - e-NPV)

**CONCLUSION**

Sliding platform doors are a very important structure of the metro transport infrastructure, ensuring safety, passenger flow management, and energy efficiency. Analysis of design solutions (automatic platform gates, full and half-height systems, "horizontal lift") and dynamic characteristics (climate control, synchronization, and automation) shows the adaptability of these doors to metropolitan conditions. Materials such as aluminum alloys, tempered glass, and composite materials contribute to compliance with safety and durability standards. FH-PSD sliding platforms used in Beijing and Singapore provide maximum insulation and integration with automated systems, and APG and HH-PSD used in London and Tokyo offer practically effective solutions for station modernization.

For the Tashkent Metro, given the climatic conditions (hot summer, cold winter), increasing passenger flow, and the need to modernize existing stations, the most effective option is half-height platform doors or automatic platform gates. The advantages of these - lower cost and simplified adaptation to existing stations - make them the optimal solution for modernization, which is especially relevant for the old lines of Tashkent. At the same time, HH-PSD and APG provide a sufficient level of safety and passenger flow management, although they are inferior to FH-PSD in climate control and noise insulation. For new lines with high passenger traffic and automated trains in the future, it is advisable to consider the implementation of FH-PSD integrated with ATO and IoT systems to improve energy efficiency and comfort. The prospects for the development of PSD in Tashkent are associated with the introduction of energy-efficient technologies and AI, which will ensure sustainable and safe urban mobility in the context of urbanization.

**FUTURE SCOPE**

Platform sliding doors (PSD), also known as platform screens or horizontal barrier fencing systems, are engineering systems installed at metro stations along the edge of the platform. The main purpose of these platforms is to ensure the safety of passengers, prevent falls on the track, and also optimize unloading.

Technical and operational advantages; Modern research in the field of transport engineering shows that PSD contribute to: reducing accidents: eliminating passenger access to the track space before the train arrives; improving the microclimate at stations: reducing air flows from the movement of trains, which simplifies temperature and dust control; increasing energy efficiency: due to the insulation of the tunnel space, the energy consumption of ventilation systems is reduced; optimizing the flow of passengers: synchronizing the platform doors with the train doors streamlines the unloading flows.

Future Applications; With the development of digital technologies and intelligent transport systems, active implementation of PSD is predicted in the following areas:

Automated and driverless trains PSD are becoming a mandatory element of infrastructure in the transition to driverless systems, where safety and stopping accuracy are critical.

High-traffic metro On routes with an interval of less than 90 seconds, PSD s help to maintain the schedule, preventing delays associated with unauthorized exits onto the tracks.

Smart stations Integrating PSD s with sensor systems, cameras and biometrics will allow the implementation of access control functions, adaptive opening of zones, and monitoring of platform occupancy.

Modular and mobile stations of the future In concepts of temporary or quickly assembled transport infrastructure (for example, in areas of new construction or during mass events), PSD s can be used as part of prefabricated complexes - ensuring safety without the need for capital construction.

Increased standards of comfort and inclusiveness new generation of the PSD system will take into account the needs of people with limited mobility, integrating visual and audio signals, in addition to tactile navigation tools.

Thus, platform sliding doors are moving from the category of additional equipment to the category of key components of the metro infrastructure of the future. Their role goes beyond ensuring safety, covering energy saving, digital integration, sustainable development and inclusiveness of the urban environment.

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