KONE provides innovative and eco-efficient solutions for elevators, escalators and automatic building doors. We support our customers every step of the way; from design, manufacturing and installation to maintenance and modernization. KONE is a global leader in helping our customers manage the smooth flow of people and goods throughout their buildings.

Our commitment to customers is present in all KONE solutions. This makes us a reliable partner throughout the life-cycle of the building. We challenge the conventional wisdom of the industry. We are fast, flexible, and we have a well-deserved reputation as a technology leader, with such innovations as KONE MonoSpace®, KONE MaxiSpace®, and KONE InnoTrack®. You can experience these innovations in architectural landmarks such as the Trump Tower in Chicago, the 30 St Mary Axe building in London, the Schiphol Airport in Amsterdam and the Beijing National Grand Theatre in China.

KONE employs over 34,000 dedicated experts to serve you globally and locally in over 50 countries.
# Table of Contents

1. **Introduction** ........................................................................................................... 4  
2. **Concepts behind People Flow™ planning** ........................................................... 7  
   2.1 Circulation concepts ........................................................................................... 7  
   2.2 Passenger characteristics .................................................................................. 11  
   2.3 Passenger routing .............................................................................................. 15  
   2.4 Station types ...................................................................................................... 19  
   2.5 Platforms ........................................................................................................... 20  
3. **Number of devices per level** ................................................................................. 3  
   3.1 General planning principles ............................................................................. 23  
   3.2 Building doors ................................................................................................... 25  
   3.3 Platform screen doors ....................................................................................... 27  
   3.4 Turnstiles & ticketing ....................................................................................... 28  
   3.5 Stairways .......................................................................................................... 29  
   3.6 Escalators .......................................................................................................... 30  
   3.7 Horizontal and inclined autowalks ................................................................. 34  
   3.8 Elevators .......................................................................................................... 35  
   3.9 Planning tools .................................................................................................... 38  
4. **References** ............................................................................................................. 40
1. Introduction

Transit stations are characterized by the absence of a static or permanent population, and the presence of pulsating, heavy flows of people moving through a space. In such an environment, it is essential that people can move forward smoothly without forming cumulative queues during their journey through the station. Circulation in transit stations requires careful planning of all transportation devices so that their handling capacities will meet the peak traffic demand. Circulation in a station has to be fluent every day, and station evacuation also has to be considered during the design phase.

Transportation planning is done early in the design process when the decision has been made to construct the metro or railway line, and there is a preliminary estimation of the number of stations and their locations. The city plan provides key information, as it shows both the current and the future development of station surroundings, which also affect the expected People Flow through the stations.

When all this information is collated, the means of vertical transportation of each station can then be defined on the basis of the number of passengers flowing through the stations.

Today’s sophisticated transportation systems give passengers smooth, pleasant and safe travel experiences. Selecting the most suitable equipment – elevators, escalators, autowalks and automatic doors – sizing them correctly and locating them to optimize People Flow, are key issues in the design of properly functioning transit stations for metros and railway traffic.

The purpose of this planning guide is to provide guidelines for determining the number of transportation devices, their size, and their locations in a transit station. Detailed product information, such as dimensions, duty classes and specific features, is found in separate Escalator & Autowalk planning guides. [1] [2]
2. Concepts behind People Flow™ Planning

2.1 Circulation concepts

Traffic in transit stations is heavy for 16 - 24 hours a day. Times when traffic peaks occur vary depending on the country, culture, location and type of the station. The wear on transportation devices (e.g. number of elevator starts), strongly correlates to the length of time the station is open to the public. Often the heaviest traffic peaks are after working hours. In the Helsinki metro the maximum number of station visitors is about 12000 persons per hour as shown in Figure 2.

![Figure 2. People Flow during the day in a transit station](chart.png)
**Terminology**

The key terms used in conjunction with People Flow™ planning and circulation are explained in Figure 3 and Table 1.

**Service quality parameters**

<table>
<thead>
<tr>
<th>Event</th>
<th>Previous elevator leaves</th>
<th>Passenger arrives/joins the waiting queue</th>
<th>Passenger enters the transport/serving elevator opens doors</th>
<th>Next elevator leaves</th>
<th>Doors start to open at destination floor</th>
<th>Passenger exits the equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journey time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiting time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3. Definitions of service quality parameters**

**Table 1. Terminology for People Flow planning**

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval</td>
<td>The time between elevator departures from the main floor. The time between train arrivals at the station.</td>
</tr>
<tr>
<td>Waiting time</td>
<td>The time from the moment a person joins the waiting queue until the serving elevator arrives and starts to open its doors, or a person can enter an escalator.</td>
</tr>
<tr>
<td>Transit time</td>
<td>Time for loading and traveling with a device until arriving at the destination.</td>
</tr>
<tr>
<td>Journey time</td>
<td>Time an individual spends waiting and traveling with a device until arriving at the destination and exiting the device, or arriving at the escalator landing plate.</td>
</tr>
<tr>
<td>Evacuation time</td>
<td>Total time from alarm until all passengers are out of the building (rescue area).</td>
</tr>
<tr>
<td>Egress time</td>
<td>Time it takes for all passengers to ascend/descend to the exit floor. Reaction time is not included in the egress time.</td>
</tr>
<tr>
<td>Level of Service (LOS)</td>
<td>Classifies the different facilities according to the space available for individuals (e.g. crowded places have a lower LOS).</td>
</tr>
<tr>
<td>Handling / transportation capacity</td>
<td>Number of people or percentage of building population that elevators, escalators, stairs, doorway, train, etc. can carry within a given time, usually five minutes or one hour.</td>
</tr>
<tr>
<td>Rated capacity</td>
<td>Number of persons that a device can carry (elevator car size in persons or people per escalator step).</td>
</tr>
<tr>
<td>Rated load</td>
<td>Load in kilograms that an elevator or escalator can carry in normal circumstances.</td>
</tr>
<tr>
<td>Load / utilization factor</td>
<td>The current number of passengers as a percentage of the rated capacity.</td>
</tr>
</tbody>
</table>

**Level of service**

Level of Service (LOS) is based on Fruin pedestrian queuing tables in lobbies, waiting areas, stairways and corridors. The Fruin tables describe the density of people in a given area. They can be used as one of the decision variables when planning transit stations. Level of Service is a classification scheme, in which classes A-F are applied according to the space available for individuals. Class A corresponds to the situation where people have plenty of space around them. At the other extreme, class F means congestion. Table 2 and Figure 4 show examples of LOS classes.

**Table 2. LOS definition by Fruin**

<table>
<thead>
<tr>
<th>LOS</th>
<th>Definition</th>
<th>Pedestrian space (m²/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Free Circulation Zone</td>
<td>≥ 3.3</td>
</tr>
<tr>
<td>B</td>
<td>Restricted Circulation Zone</td>
<td>2.3 – 3.3</td>
</tr>
<tr>
<td>C</td>
<td>Personal Comfort Zone</td>
<td>1.4 – 2.3</td>
</tr>
<tr>
<td>D</td>
<td>No Touch Zone</td>
<td>0.9 – 1.4</td>
</tr>
<tr>
<td>E</td>
<td>Touch Zone</td>
<td>0.5 – 0.9</td>
</tr>
<tr>
<td>F</td>
<td>The Body Ellipse</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>
2.2 Passenger characteristics

People Flow™ is affected by three main factors regarding passengers:

- The number and characteristics of the people passing through.
- The layout and locations of the facilities.
- How people find their way in a station, and the type of buildings in the surrounding area.

The types of passengers expected to pass through the station also define the types of facilities that are required. At the same time, the number of passengers during peak hours determines the required number of facilities. Finally, layout and location of the facilities affect the ease of use: a logical sequence of the facilities in addition to good signage is needed for efficient navigation. All these aspects of the People Flow need to be well-defined in the station design by considering the human factors and characteristics discussed in this section.

Figure 4. Examples of different levels of service

LEVEL OF SERVICE A
Walking speeds freely selected; conflicts with other pedestrians unlikely.

LEVEL OF SERVICE B
Walking speeds freely selected; pedestrians respond to presence of others.

LEVEL OF SERVICE C
Walking speeds freely selected; passing is possible in unidirectional streams, minor conflicts for reverse or cross movement.

LEVEL OF SERVICE D
Freedom to select walking speed and pass others is restricted; high probability of conflicts for reverse or cross movement.

LEVEL OF SERVICE E
Walking speeds and passing ability are restricted for all pedestrians; forward movement is possible only by shuffling; reverse or cross movements are possible only with extreme difficulty; volumes approach limit of walking capacity.

LEVEL OF SERVICE F
Walking speeds are severely restricted; frequent, unavoidable contact with others; reverse or cross movements are virtually impossible; flow is sporadic and unstable.
**Cultural differences**

Physical and behavioral characteristics vary between people but are mostly affected by local customs, manners and other cultural issues. Some cultural aspects are presented in Table 3.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking speed</td>
<td>In larger cities of East Asia and Europe (e.g. Singapore, Copenhagen, Madrid), average walking speed can reach 1.7 m/s, whereas in cities in the Middle East (e.g. Manama, Amman, Damascus, Dubai), people walk more slowly, at 1.0 - 1.2 m/s [14]</td>
</tr>
<tr>
<td>Walking side</td>
<td>People tend to walk on the same side of a passageway as their traffic flow. Left-hand traffic in 75 countries, including U.K., Australia, Thailand, India, Japan, South Africa, right-hand traffic in 164 countries. [15]</td>
</tr>
<tr>
<td>Social distance</td>
<td>Asian and Latin people accept closer distance than western cultures [16]. On the other hand, in Arabic countries social distance seems to be greater.</td>
</tr>
<tr>
<td>Age distribution</td>
<td>Western countries have a larger percentage of elderly people.</td>
</tr>
<tr>
<td>Prevalence of disabilities</td>
<td>In high-income countries older people make up a greater proportion of the population but have lower levels of disability than their counterparts in low- and middle-income countries. Moderate disability rates are similar for males and females in high-income countries, but females have somewhat higher rates of severe disability. [13]</td>
</tr>
<tr>
<td>New users</td>
<td>In some countries there are people who have never used an escalator or elevator.</td>
</tr>
<tr>
<td>Moving aids</td>
<td>In some countries, disabled people rarely use wheelchairs, which are commonly used in western countries.</td>
</tr>
<tr>
<td>Prams</td>
<td>In some cultures prams are not used at all.</td>
</tr>
<tr>
<td>Bicycles</td>
<td>In some countries, bicycles are used and transported in the subways more than elsewhere.</td>
</tr>
<tr>
<td>Waiting time</td>
<td>In East Asia people do not mind waiting as much as in western countries.</td>
</tr>
<tr>
<td>Ride comfort</td>
<td>In East Asia people prefer ride comfort inside the elevator whereas in North America elevator efficiency (e.g. higher elevator acceleration) is preferred.</td>
</tr>
<tr>
<td>Walking on escalators</td>
<td>In many countries, one side is for standing, and the other for walking. However, in some countries (e.g. India), people stand on both sides, and only the first few people walk up the escalator.</td>
</tr>
</tbody>
</table>

**Age distribution**

Compared to the general population, passengers using public transportation tend to be mainly adults, with fewer children and elderly people.

An example of age distribution in the USA is shown in Figure 5.

**Disabilities**

Disabilities can affect the walking speed and the space required for moving (e.g. when people are using moving aids). Disability prevalence is 4 - 17% of the population depending on the country. \[17\] 2.9% of the world’s population (in 2004) was severely disabled and up to 12.4% had moderate long-term disability. Disabilities are more common amongst elderly people. 46% of disabled people are over 60 years old. \[8\]

**Walking speed**

Average walking speed in passageways is between 0.7 - 2.0 m/s \[18\], and is getting faster, especially in larger cities. When designing, a value of 1.25 m/s should be used \[3\]. Men tend to walk faster than women \[6\], and people with disabilities will usually walk more slowly. The faster people walk, the more space they tend to keep around themselves.

With a high LOS, people can walk freely as fast as they wish. In tight situations, people are forced to reduce their speed. Average walking speeds with different LOS are presented in Table 4.
2.3 Passenger routing

Optimizing routes
When designing transportation devices, the passenger routes need to be studied before determining the solutions. There should always be at least one completely accessible route from the entrance to the train and back for disabled people. Preferably all routes should be accessible for all.

When people are walking inside familiar surroundings, they tend to optimize their routes in order to get to their destination faster, more easily or more pleasantly. Some people may want to avoid queuing while others may not want to use several transportation methods, or might prefer to use elevators. Frequent passengers especially try out different routes to find the optimal way, and then use it. New users take a shortcut when they see one, or follow other people and their paths to reach their destination. Infrequent users do not see the whole route and tend to avoid going in the opposite direction of the destination, even though a small detour might turn out to be a faster route.

Path optimization takes place throughout the whole route:

Choosing escalators, stairs or elevators
Transport selection are based on estimates for the distribution of people using the escalator, elevator or stairs. When moving between floors, people choose equipment:

- Along their optimal route (fastest, easiest, most pleasant).
- That is closest. Particularly when coming out of a crowded metro train, the nearest way out is chosen.
- That others choose, especially if the passenger is not sure where to go.

Table 4. LOS definitions for pedestrian speed on horizontal autowalks

<table>
<thead>
<tr>
<th>LOS</th>
<th>Definition</th>
<th>Horizontal walking speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Free Circulation Zone</td>
<td>1.3</td>
</tr>
<tr>
<td>B</td>
<td>Restricted Circulation Zone</td>
<td>1.25</td>
</tr>
<tr>
<td>C</td>
<td>Personal Comfort Zone</td>
<td>1.22</td>
</tr>
<tr>
<td>D</td>
<td>No Touch Zone</td>
<td>1.15</td>
</tr>
<tr>
<td>E</td>
<td>Touch Zone</td>
<td>0.77</td>
</tr>
<tr>
<td>F</td>
<td>The Body Ellipse</td>
<td>&lt; 0.77</td>
</tr>
</tbody>
</table>

Traveling alone / with a group
When people travel alone, they are more focused on their environment, whereas people traveling in groups might have their attention on each other. With larger groups the walking pace declines. Also when traveling in a group, the routes are chosen so that everyone will take the same route: if one person goes to the elevator, everyone will use it.

Adapting to the crowds
New travelers see how other people are behaving and will use the routes others are using. The need for personal space means that people will adjust their walking speed according to other people in crowded situations, and walk more slowly if the crowd moves more slowly.

Route choice is affected by other people. While people will take routes used by others, extremely crowded routes are avoided if other possible routes are known. [1]
The distribution of people using stairs, escalators and elevators is not always the same, but depends on:

1. **The location of transportation devices.** People take the equipment on the optimal path.
2. **Amount of equipment.** If there are only a few escalators with long queues to them, it might be faster to take the stairs. The length of the queue depends on the number of the equipment.
3. **The height between floors.** With small differences in levels, stairs are more easily chosen.
4. **The condition of the equipment.** Escalators or elevators that seem to be damaged, dirty or make a strange sound are used less.

In locating the equipment, the routes that people use need to be identified, and then equipment (especially the primary means of transportation, often escalators) should be located along that path.

**Need for guidance**

People find their way through a station faster when they are familiar with the place. First-time users need guidance, instructions to use equipment and clearly laid-out solutions, whereas frequent users can navigate their way through more complex settings. New users rely many times on the information received from other passengers. They prefer those routes which others are using. For frequent users problems might occur when new arrangements are made and walking paths have to be changed. They then require guidance to navigate their way through the station.

The proportion of frequent users increases during rush hours and weekdays, while there are more new users during daytime, weekends and holidays. Frequent users tend to take the fastest possible route, whereas tourists might walk at a slower pace.

Successful way-finding can be helped by guidance systems, in which display content, systems design, location of the signage and symbols play an important role. Their design needs to be consistent and the terminology understandable: there should not be too much guidance information. People need information about:

- Their current location within the facility.
- Possible destinations.
- Which route to choose in order to get to the destination.

Navigation guidance is needed throughout the routes of the passengers from finding the entrance to the gates to the platform, getting transit schedule information, leaving at the correct destination to finding the correct direction out of the exit. Also, there could be information about rest-rooms, emergency services, fare information etc. To find the correct information, the signage needs to be located at those places where people can get the information they need. With the KONE MovingMedia solution even the escalator steps can be used for guidance purposes.
2.4 Station types

There are two different station types: regular stations and transfer stations. If the station is a transfer station between two or more metro lines, the number of passengers traveling between the platforms can be much greater than people entering or exiting the station. The transfer connection stations hold the key to dimensioning People Flow™. In a transfer connection station, people are arriving as a large group from the other platform. This means the People Flow is more dense.

To avoid congestion problems, the vertical transportation devices need to be able to handle equally heavy People Flow in both directions. The people should be able to move from the arrival platform to the connection platform. Within a train interval, people must not block the way for the passengers coming with the next arriving train.

Table 5. Comparisons between a regular and a transfer station

<table>
<thead>
<tr>
<th>Station type</th>
<th>Use</th>
<th>Effects on People Flow infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular station</td>
<td>• Used for entering and exiting a station</td>
<td>• Traffic flow between entrances and platform</td>
</tr>
<tr>
<td>Transfer station</td>
<td>• Used mainly for changing trains</td>
<td>• Most traffic between platforms</td>
</tr>
</tbody>
</table>

The number of transportation devices in a station is based on the station usage, which depends on the type of station and its surrounding area. If the area has residential buildings, their population affects the rush hours, since people are going to work or school, and the main passenger flow in the morning is TO the station. If the area has schools or offices, the main traffic flow in the morning is FROM the station.

If there are attractions near the station such as stadiums or concert halls, traffic peaks will appear at the end of an event.

The maximum number of people leaving the attraction within a defined time period (e.g. half an hour) should be estimated. The number of people arriving at that station can be estimated from the capacity of each car, the number of cars per train, and the interval of the trains. Table 6 presents some examples of how a station’s surrounding area can affect the use of vertical transportation devices.

Table 6. Effects of a station’s surrounding area of a station on People Flow

<table>
<thead>
<tr>
<th>Surrounding area</th>
<th>Characteristics</th>
<th>Effects on escalators, stairs and elevators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial area / shopping centers</td>
<td>• Certain opening hours and days</td>
<td>• Less load on escalators</td>
</tr>
<tr>
<td></td>
<td>• People carry items to the train</td>
<td>• Peaks during opening and closing hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less traffic when markets are closed</td>
</tr>
<tr>
<td>Stadiaums / concert halls</td>
<td>• Very heavy traffic peaks at the end of the event</td>
<td>• If present, elevators could be used more (when people carry heavy items)</td>
</tr>
<tr>
<td>Offices</td>
<td>• Mainly office people</td>
<td>• Occasional extremely heavy use on elevators and escalators</td>
</tr>
<tr>
<td>Long distance transfer connections (e.g. bus terminal)</td>
<td>• People have luggage</td>
<td>• Most of the transportation devices should serve the main direction of flow</td>
</tr>
<tr>
<td></td>
<td>• More new users</td>
<td>• Fastest and optimal routes are used most</td>
</tr>
<tr>
<td></td>
<td>• More people in groups</td>
<td>• Heavy traffic during rush hours (in certain directions)</td>
</tr>
<tr>
<td>Attractions nearby</td>
<td>• More tourists (first-time passengers)</td>
<td>• Less crowded during daytime and on holidays</td>
</tr>
<tr>
<td></td>
<td>• More foreign people</td>
<td>• Clear layout and guidance needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Holidays and seasons affect the number of passengers</td>
</tr>
</tbody>
</table>
2.5 Platforms

The practical service standard for a metro platform is clearance of the platform before the arrival of the next peak period train. Station platforms where people move from platform level to other floors are extremely critical for designing People Flow™. Even though people may come to the platform in large groups, crowds are more typical when the train is emptying. The minimum requirement is to have the people off the platform before the next train arrives.

Platform type

There are two types of platform configurations: center platforms and side platforms, which are illustrated in Figure 7.

Platform width

Platforms of busy stations must be wide enough for the estimated number of passengers queuing for the train, and getting off it. Queuing and entering the train can be supported by marking the locations to enter the train. This can be done by barriers with opening doors, barriers with doorways or floor markings (paint or texture).

Platform entries and exits

Platforms of busy stations should be designed so that when passengers arrive at the platform floor, they can clearly see where to go. When visibility is limited, people do not see if there is space somewhere else, so they start to queue immediately after reaching the platform.

Figure 7. Two main types of platform configuration: side platform and center platform

On a center platform, the total number of vertical transportation devices can be less than on side platforms, but the handling capacity calculations need to account for passengers coming from both trains. A busy center platform needs to be wide enough for people to queue for both trains. [11]

On a side platform, the handling capacity of the whole station is greater since there are more vertical transportation devices. The queues to the trains will not get mixed, and the main traffic flows are more separate, which makes it easier to handle People Flow™. [11] Side platforms could be designed so that the width can be increased later if greater capacity is required.

Figure 8. With several platform exits people will be spread more evenly along the platform and in the metro

People tend to enter the train from an optimal spot, which later allows them to get off the train and leave the destination platform as quickly as possible. If all the stations will have platform exits in similar places, those parts of the train will be extremely crowded. Therefore, the location of platform exits in different stations varies.
3. Number of devices per level

3.1 General planning principles

In elevator, escalator, autowalk and automatic door planning, the peak traffic flow is approximated, and the number of transportation devices should meet the peak traffic demand. When planning the number and type of devices the following items should be considered:

- When designing a new station, space could be left for adding escalators later on, if necessary (e.g. by replacing stairs or in a space reserved especially for escalators).
- The handling capacity should be calculated so that if an escalator or an elevator is out of service, other equipment will be able to handle the peak traffic.
- Two elevators for each floor would be the best solution, to ensure an accessible route for people in wheelchairs.
- Handling capacity calculations need to cover both directions of People Flow™.

Table 7. Example of one-way traffic and the number of equipment needed (5 meter vertical rise).

<table>
<thead>
<tr>
<th>Passenger flow using the devices</th>
<th>Number of devices</th>
<th>Width / capacity (persons/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escalators, 0.5 m/s</td>
<td>80 %</td>
<td>5760</td>
</tr>
<tr>
<td>Stairs</td>
<td>15 %</td>
<td>1080</td>
</tr>
<tr>
<td>Elevators</td>
<td>5 %</td>
<td>360</td>
</tr>
<tr>
<td>In total</td>
<td>7200</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Example of one-way traffic and the number of equipment needed (15 meter vertical rise).

<table>
<thead>
<tr>
<th>Passenger flow using the devices</th>
<th>Number of devices</th>
<th>Width / capacity (persons/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escalators, 0.5 m/s</td>
<td>70 %</td>
<td>5040</td>
</tr>
<tr>
<td>Stairs</td>
<td>0 %</td>
<td>0</td>
</tr>
<tr>
<td>Elevators</td>
<td>30 %</td>
<td>2160</td>
</tr>
<tr>
<td>In total</td>
<td>7200</td>
<td></td>
</tr>
</tbody>
</table>

Elevator groups should have free space of 3 meters, or 1.5 times the car depth, whichever is greater or twice the car depth if elevators are opposite each other. Elevators should be located so that they are easily accessible for people in wheelchairs, and the queue in front of them does not disturb passenger flows. Devices can also be located so that they are easy to monitor to prevent vandalism.

The People Flow™ calculations should be done for each floor so that people arriving on a metro to a platform can be smoothly transported to exits. This means that to avoid congestion problems, all subsequent floors should have as much transportation capacity as previous floors.
Since the vertical rise in Table 8 is 15 meters, people will mainly use escalators and elevators rather than stairways. Access to other levels should be ensured even if one escalator is out of service. In some countries, stopped escalators can be used as stairs. However, due to the higher step, the number of people using stopped escalators is always less than those using regular stairs. Accessibility should be considered even in maintenance situations.

Regarding a metro transfer station, the number of people changing metro lines should also be considered. Planning calculations should use the numbers of passengers or the emergency exiting requirements – whichever is greater.

The train interval is the time period between arrivals or departures and it indicates how often people are arriving at the platform levels and leaving for other floors. For a center platform – where one platform serves trains on both sides – the number of people changing metro lines should also be estimated. Planning calculations should use the numbers of passengers or the emergency exiting requirements – whichever is greater.

Between arrivals or departures, the number of people arriving at the level (from a train or other floors), and the number of people leaving the floor have to be estimated. The easiest way to estimate the People Flow in stations is to find out how often trains arrive at the station, and what percentage of the platform capacity enters and exits. The same procedure has to be used for stations 2 and 3.

Example Planning of transportation devices in transit stations is based on peak traffic flows as shown in Table 9. For each station and platform, the peak traffic flow has to be estimated separately. The number of people arriving at the level (from a train or other floors), and the number of people leaving the floor have to be estimated. The easiest way to estimate the People Flow in stations is to find out how often trains arrive at the station, and what percentage of the platform capacity enters and exits. The same procedure has to be used for stations 2 and 3.

Table 9. Alternative solutions with escalators/elevators, for example stations with a vertical rise of 8 meters (either escalators or elevators will handle the traffic).

<table>
<thead>
<tr>
<th>Station</th>
<th>Train interval</th>
<th>Peak flow</th>
<th>Flow/hour</th>
<th>Number of escalators (include both directions)</th>
<th>Escalator transportation capacity</th>
<th>Number of elevators</th>
<th>Elevator handling capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Personal/interval</td>
<td>Persons/hour</td>
<td>1000 mm/0.5 m/s</td>
<td>Persons/up-down/hour (PUI7/10)</td>
<td>Persons/hour</td>
<td>Min</td>
</tr>
<tr>
<td>Station 1</td>
<td>4</td>
<td>120</td>
<td>1800</td>
<td>2</td>
<td>12000</td>
<td>2</td>
<td>2150</td>
</tr>
<tr>
<td>Station 2</td>
<td>4</td>
<td>300</td>
<td>4500</td>
<td>2</td>
<td>12000</td>
<td>5</td>
<td>5400</td>
</tr>
</tbody>
</table>

3.2 Building Doors

Table 10. Number of 1 m wide doors needed for an entrance, according to different maximum pedestrian flows

<table>
<thead>
<tr>
<th>Maximum pedestrian flow in doorways</th>
<th>Number of doors for different LOS grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons/min</td>
<td>B - Restricted Circulation Zone</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>300</td>
<td>7</td>
</tr>
<tr>
<td>400</td>
<td>10</td>
</tr>
</tbody>
</table>

People enter a station through manual or automatic swing doors or automatic sliding doors, except in Asian countries where entrances do not usually have doors. Automatic revolving doors are not recommended due to lower capacity and risks especially during evacuation or emergencies. On the entrance floor, the number of doors and the width of the doorways need to match the maximum number of people coming from other levels to the exit floor, and the maximum amount of people entering the station.

Preferably all the entrances would be accessible for wheelchair users but if compromises are made, elevators should be located in close proximity to those entrances with the most traffic. The usage of entrances can be estimated from the use of the surrounding area and its buildings. Exits close to attractions and public or high-rise buildings are naturally used most.

In view of evacuation or emergency situations it is often required that all door mechanism at the entrance of the stations are fail-safe. Redundant break-out systems (batteries, bungee cords etc.) should also be used in the door panels. Regulations from local regulatory bodies and governmental agencies must be applied in the design of the entrances and building doors (fire departments, building counsels, Health and Safety counsels etc.).

The capacity of building doors should be based on the worst case; either on the maximum traffic from the trains to the outside of the station (based on the number of passengers in the trains arriving), or based on the maximum flow from the buildings surrounding the area around the station to the trains. In addition, the handling capacity of all transfer units needs to be balanced; (metro) trains, elevators, escalators and the building doors and turnstiles must always be aligned to prevent safety hazards for people waiting and standing on platforms. Particularly when platform screen doors are not used, there may be a risk of overcrowding and people falling on the railway tracks.
3.3 Platform screen doors

Platform screen doors (or automatic platform gates) are automatic sliding doors or gates at the edge of railway platforms for metro, light rail or other train systems, to prevent passengers falling off the platform edge onto the railway tracks (see Figure 10). The platform doors or gates slide open or close simultaneously with the train doors.

The height of the platform screen doors can vary between low-, middle- and full-height. Also, screen doors can be integrated in a full-height dividing wall, which creates a separate compartment between tunnel/track and platform. The dividing walls are usually steel structures with glass panels.

Platform screen doors improve the People Flow™ by guiding the people to the correct location on the platform to enter trains, which also creates a more fluent flow of people on the platform. The effect of platform screen doors can be further enhanced by applying signs or direction indicators on the floor near them, in order to improve the exit/entry flow between train and platform.

Compared to full-height platform screen doors, half-height platform gates are cheaper to install as they require a smaller metallic framework for support. Some railway operators prefer such an option to improve safety at railway platforms and, at the same time, keep costs low and non-air-conditioned platforms naturally ventilated. However, platform gates are less effective compared to platform screen doors in preventing people from jumping or throwing objects onto the tracks.

The main advantages of platform screen doors are:
- Safety (reduce accidents, people falling on tracks/suicides – only for full-height doors).
- More reliable service and schedule of the metro system (less disturbance).
- Security (restrict access to tracks and tunnels).
- Prevent litter on the track (reduce maintenance/cleaning costs, risks for fire etc. – only for full-height doors).
- Increased comfort for travelers (dust, noise, wind, better information where to enter the train).
- Enable Automatic Passenger Movers (APMs, i.e. trains without operators).
- Better People Flow (shorter exit and entry time, train can spend less time at station).

Figure 10. Example of platform screen doors

Planning the number of doors:

1. Estimate maximum People Flow through doors in persons per hour, or persons per interval (special provision can be made in case special events are expected)
   - e.g. 300 persons /5 min = 60 persons/min
2. Select LOS and the flow per unit width, from the Table 11
   - C: convenient, so: 33-49 persons/min from 1 m wide doorway
3. Select door width, for example 1.5 m.
4. Calculate pedestrian flow per interval or per hour by multiplying the flow per unit width (from step 2) by the door width
   - 50.74 persons/min from 1.5 m wide door
5. Determine the number of doors by dividing the estimated People Flow by pedestrian flow per interval (interval should be the same in both estimated and calculated pedestrian flow)
   - 1 door of 1.5 m width would be enough for 60 persons/min.
6. Consider reverse flow: There are some people coming from the opposite direction.
   - 2 doors would guarantee smoother flow at a convenient Level of Service.
3.4 Turnstiles & ticketing

After entering a station, people come from the unpaid area to the boundary of the paid area, or ticketing area. There can be a security check, ticketing point, and turnstiles in this area. The order of these should be clear and the layout should guide people to the correct route. People Flow™ through the intermediate floors between the entrance floor and the platform (also called mezzanine floor, concourse level, ticketing level etc.) should not have any bottlenecks.

Turnstiles make people enter one by one to their next locations. The interval between people coming through these points is dependent on the turnstile type and whether a ticket is shown or inserted into the system. A manual gate for disabled people and prams is also needed.

Table 12. Pedestrian volume of turnstiles

<table>
<thead>
<tr>
<th>Type of entrance</th>
<th>Observed average headway (s)</th>
<th>Equivalent pedestrian volume (persons/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free admission (barrier only)</td>
<td>1.0 - 1.5</td>
<td>40 - 60</td>
</tr>
<tr>
<td>Ticket collection by staff</td>
<td>1.7 - 2.4</td>
<td>25 - 35</td>
</tr>
<tr>
<td>Single-slot coin- or token-operated</td>
<td>1.2 - 2.4</td>
<td>25 - 50</td>
</tr>
<tr>
<td>Double-slot coin-operated</td>
<td>2.5 - 4.0</td>
<td>15 - 25</td>
</tr>
<tr>
<td>Card reader (various types)</td>
<td>1.5 - 4.0</td>
<td>25 - 40</td>
</tr>
<tr>
<td>High entrance/exit turnstile</td>
<td>3.0</td>
<td>20</td>
</tr>
<tr>
<td>High exit turnstile</td>
<td>2.1</td>
<td>28</td>
</tr>
<tr>
<td>Exit gate, 3.0 ft (0.9 m) wide</td>
<td>0.8</td>
<td>75</td>
</tr>
<tr>
<td>Exit gate, 4.0 ft (1.2 m) wide</td>
<td>0.6</td>
<td>100</td>
</tr>
<tr>
<td>Exit gate, 5.0 ft (1.5 m) wide</td>
<td>0.5</td>
<td>125</td>
</tr>
</tbody>
</table>

3.5 Stairways

Simple layouts are the best. Stairways should be spread out to the areas where people arrive at the station. Stairs are good for small level differences, but the longer the stairs, the less they are used as people prefer escalators and elevators. For a very high vertical rise, stairs are used very little.

If there is a lot of traffic in the opposite direction, stairs easily become crowded and cause congestion problems. To improve this, floor markings (i.e. a line separating walking lanes, and direction arrows) can be added to provide guidance on moving directions – right-hand/left-hand traffic according to the local traffic flow.

Transportation capacity in stairways

When walking on stairs, people need space of 3 steps in the longitudinal direction before the person in front of them, as shown in Figure 11. When walking down the stairs, people tend to leave more space in front of them. \[6\]

Stairs can be planned for short vertical rises, and as emergency exits. Staircases can be planned instead of escalators, parallel to escalators, and as an alternative means of transportation if the escalators should fail. If escalators are placed next to stairways, an inclination of 27.3 degrees is recommended. Local legislation determines guidelines for adequate stairway dimensions. It is recommended that stairways with combined width more than 2.2 m should be divided into several lanes so that each lane is preferably 1.2 - 1.8 m wide. \[13\]

Transportation capacity of stairways can be calculated assuming 0.72-1.0 persons per second per width of one meter. \[3,18\] If there is counter flow in stairs, the combined width should be increased at least by 0.75 m.

The minimum combined staircase width (W) is:

\[
W = \frac{F}{f},
\]

where

- \( F \) is passenger flow \( \text{[persons/min]} \)
- \( f \) is nominal flow in stairs \( 30-60 \text{ persons/min/m} \)

Planning the stairs

1. Estimate the peak traffic People Flow using the stairs e.g. 60 persons/min
2. Select the nominal flow \( f \) (e.g. \( 0.72 \text{ persons/s/m} = 43.2 \text{ persons/min/m} \))
3. Solve minimum combined stairway width \( W \) (\( 60/43.2 = 1.39 \text{ m} \))
4. Divide the combined width into one or several preferably 1.2 - 1.8 m wide channels.
3.6 Escalators

Moving direction
When escalators are located side by side, their moving direction should be according to the local traffic flow, if the layout does not suggest otherwise (e.g. left-hand side traffic in U.K., India etc.). This prevents people crossing each other at both ends of the escalator, since in wide passageways people tend to walk on the side of the traffic flow.

If the direction of the majority of the People Flow™ changes heavily according to the time of day (e.g. people going to the offices in the morning and returning home in the evening), the moving direction of escalators can be changed accordingly. In case of several parallel escalators, this is easily executed by changing the direction of the escalators in the middle as presented in Figure 13.

If escalators do not stop entirely, but move slowly in energy saving mode, it is easier for people to perceive the direction of the escalator. The correctly moving direction can also be indicated by traffic lights in front of the escalator.

In quieter stations escalators stop when nobody is using them. When a person approaches it from either end, it will start moving so that the person can use it.

Crowded escalators
In busy stations people can form tight crowds in front of escalators. With many people trying to enter an escalator from different directions at the same time, the actual loading percentage of an escalator might stay rather low.

Using slower escalators
Slower escalators with a speed of 0.5 m/s should be preferred especially in:
- Places where there are many new escalator users.
- Stations where people arrive after having traveled for a long time (e.g. bus/train stations). People may have heavy luggage with them, or may just be tired. Accidents have been reported from these kinds of stations with faster escalators.
- Market places where people might be carrying heavy bags.

To make it easier to enter an escalator, and to increase the loading percentage and improve passenger safety, changes can be made:

1. **Railing arrangements** beside the escalator guide people to form a queue already a bit before entering, so that the crowd is not squeezed against moving handrails. It also prevents accidents from crowds leaning on the moving handrail from the sides (Figure 14).
2. **Three poles** in front of an escalator will guide people to form two lines before entering it. They also prevent people with large luggage from using the escalators (Figure 14).
3. **Adding a separator line** in the middle of the escalator can guide people to stand on the sides rather than in the middle (Figure 14).
4. **More space before and after an escalator** gives room for the queue to form, and for people to exit.
5. **Designing walking paths** so that people do not have to walk through queues.
Escalator transportation capacity
The maximum capacity of escalators according to EN115-1 is shown in Table 13.

Table 13. Maximum capacity of escalators or horizontal/inclined autowalks according to EN 115-1:2008 [14]

<table>
<thead>
<tr>
<th>Step/pallet width mm</th>
<th>Nominal speed m/s</th>
<th>0.50</th>
<th>0.65</th>
<th>0.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>3600 persons/h</td>
<td>4400 persons/h</td>
<td>4900 persons/h</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>4800 persons/h</td>
<td>5900 persons/h</td>
<td>6600 persons/h</td>
<td></td>
</tr>
<tr>
<td>1000*</td>
<td>6000 persons/h</td>
<td>7300 persons/h</td>
<td>8200 persons/h</td>
<td></td>
</tr>
</tbody>
</table>

NOTE 1 Use of baggage carts will reduce the capacity by approximately 80%.
NOTE 2 For horizontal/inclined autowalks with a pallet width in excess of 1.00 m the capacity is not increased as users need to hold the handrail; the additional width is mainly to enable the use of shopping trolleys and baggage carts.

In Table 13, about 0.7-0.8, 1.0-1.1 and 1.2-1.3 persons per step are assumed for the 600 mm, 800 mm and 1000 mm wide escalators respectively. Density of passengers on an escalator depends very much on the culture. In a KONE study during rush hours at the Delhi metro station, escalators were observed to be 60% loaded at the maximum, that is 1.2 persons per step in a 1000 mm wide escalator, which corresponds to a person on every step and 2 persons on every 5th step.

In crowded situations, the following issues have an effect on the escalator transportation capacity:
- Social distance affects how close to each other people stand. When people are standing more closely to each other, load can be larger.
- New users and large amounts of luggage will decrease the load.

Figure 15. Effect of escalator width and speed on transportation capacity

Planning the number of escalators
1. Estimate the People Flow in both up and down directions in a peak traffic situation. Note that if there are parallel stairs, divide the traffic between the stairs and escalators.
2. Select the speed and width that match the purpose (usually 0.5 or 0.65 m/s and 1000 mm wide). Transportation capacities are shown in Table 13.
3. Divide the peak flow by the transportation capacity of one escalator to find out how many escalators are needed. (Round up to the nearest integer).
4. Increase the number of escalators by one for counter-flow.
5. Increase the number of escalators by one for breakdowns (to enable the stairway or people walking on the stopped escalator to be able to compensate for the loss).

Effect of people walking
Even though the transportation capacity of escalators could be theoretically greater when people are walking on the other side, in practice it does not significantly increase escalator capacity. [1]

In some countries, people are allowed to walk on a stopped escalator, and it is not restricted with barriers. The capacity of a stopped escalator is somewhat smaller than the capacity of a stairway, because the steps are higher and deeper than on stairways.

Recommendations
The usual step width of escalators in transit stations is 1000 mm. The usual speeds are 0.5 m/s or 0.65 m/s. When the vertical distance is more than a few meters, up- and down-traveling escalators are needed instead of stairs. Often a third escalator is reserved to ensure fluent travel while maintenance is performed.

To prevent and minimize flash flood water damage, escalator entries, doorways, and stair tops should be raised above the street ground level.

In matters concerning escalator duty class and escalator features, see the Planning Guide for KONE Escalators and Autowalks.
### 3.7 Horizontal and Inclined Autowalks

**About autowalks**
Moving horizontal autowalks have high transportation capacity and are convenient for passengers with luggage or trolleys. Horizontal autowalks have an inclination of 0-6° and pallet widths of 1000, 1200, and 1400 mm. Inclined autowalks (ramps) are used to connect two floors. They have an inclination of 10-12° and pallet widths of 800 or 1000 mm. The vertical rise of an inclined autowalk (moving horizontal autowalk) is limited to 10 m.

**Number of autowalks**
The transportation capacity of inclined autowalks is the same as for escalators, see Table 12 and Figure 15. The transportation capacity of 1000 mm escalators can be used for 1200 and 1400 mm horizontal autowalks. The reason why widths exceeding 1000 mm do not increase handling capacity is that everyone must be able to reach the handrails. In practice 1400 mm wide horizontal horizontal autowalks are recommended when passengers have trolleys.

**Planning the number of horizontal or inclined autowalks**
1. Estimate the People Flow in peak traffic situation. Count each trolley as 4-8 persons.
2. Choose from Figure 15 the width and speed of the autowalk that match the objective.
3. Divide the peak flow by the transportation capacity of one horizontal autowalk to find out the number of autowalks needed (round up to the nearest integer).
4. Increase the number of autowalks by one for counter-flow (sometimes a one-way horizontal moving horizontal autowalk is enough).
5. For inclined autowalks: Increase the number of inclined autowalks by one for breakdowns (unless the stairway or people walking on a stopped horizontal autowalk are able to compensate for the loss).

### 3.8 Elevators

**Accessibility standards**
Elevators are usually needed in stations only for people who are unable to use escalators or stairways. Typically these are people with baggage and trolleys, elderly and disabled people and children. Elevators should meet the accessibility standards [16], including but not limited to:
- Cars big enough for moving aids (wheelchairs, walkers, bicycles and prams, if these are used in the location). There could also be space for a couple of moving aids to enter the elevator at the same time. (EN 81-70 gives three accessibility levels; Type 1 with 1000 x 1250 mm, Type 2 with 1100 x 1400 mm, and Type 3 with 2000 x 1400 mm, which allows a wheelchair to be rotated in the car [16]).
- Clear width of elevator doorway of at least 800 mm (Type 1), 900 mm (Type 2), or 1100 mm (Type 3) [16].
- Have buttons located properly inside the car (between 900 – 1200 mm [16]), and arrange them logically (on a single vertical/horizontal row), with tactile and auditory operating feedback.
- Accurate stopping (+/- 10 mm) and leveling (+/- 20 mm) [16].

**New users**
In developing countries there are people who have never used elevators. For them, it is important to have signalization as intuitive as possible, which means buttons in vertical rows, with descriptive symbols. The doors should open up automatically if no buttons are pressed, or in cases where elevators travel only between two floors the elevator could identify when there are passengers inside the elevator and automatically take them to the other floor, without them having to push the car call buttons.

**Car parks**
Metro stations are sometimes attached to a car park. When designing the elevators serving the parking areas, the number of parking places needs to be known. Once the parking capacity is known, the number of people that will be served by the elevators can be estimated. Typically 1.2 persons per car are assumed, but the values depend on the culture.
Planning the elevators
1. Estimate the peak traffic flow and portion of the flow using elevators. Note that elevators are usually planned for 5-20% of total flow in stations. See chapter 2.2 Passenger characteristics/ and subchapter Disabilities).
2. Select suitable car size. See handling capacity from Figure 16.
3. Select the number of elevators by dividing the peak traffic flow by the handling capacity of one car. (Round up to nearest integer).
4. Increase the number of elevators by one for breakdowns.
5. If the number of elevators is high, increase the car size.

If elevators have more than two stops, traffic analysis tools should be used (see Chapter 4.5).

Recommendations
Elevators with a capacity of at least 13 persons are able to carry objects such as a baby carriage, bicycle or stretcher. For this reason, 1600 kg is the minimum recommended capacity. For speed selection use the formula:

\[
\begin{align*}
V_{\text{excellent}} &= \frac{\text{Travelheight}}{20} \\
V_{\text{good}} &= \frac{\text{Travelheight}}{25} \\
V_{\text{satisfactory}} &= \frac{\text{Travelheight}}{32}
\end{align*}
\]

According to this formula, for instance for travel of 32 meters, a speed of 1 m/s is satisfactory, 1.6 m/s is good, and 2 m/s is excellent.

Handling capacity and level of service
If the station is more than 20-30 meters below ground, transit time with escalators becomes too long. With elevators the transit time is much shorter and they can be used as the main transportation device. The number of elevators according to vertical rise can be selected according to Figure 16.

In transit facilities, elevators often travel between two stops. For a shuttle elevator the handling capacity in persons per hour can be roughly estimated from the formula below:

\[
HC = \frac{6000 \times C}{50 + 3.6C}
\]

where \( C \) = Elevator capacity in persons (usually 17 - 26 persons)
3.9 Planning tools

Quick analysis tools
For planning elevators and escalators, traffic analysis tools can be used. On the kone.com websites the following tools are available: Planning Guide for KONE Escalators and Autowalks, Escalator Designer; MonoSpace toolbox for machine-room-less elevator dimensions; Quick Traffic to analyze the number, size and speeds of cars for bigger elevator groups; and Planulator to give the dimensions of elevators and shafts. Links to these tools can be found on KONE’s website. A simple transit station planning tool will be provided later to support this planning guide to calculate the required number of elevators and escalators. It will also give recommendations for numbers of building doors, turnstiles and autowalks. Using this tool, the required width of inclined autowalks and stairways can also be calculated, along with the handling capacity of the automatic building doors.

Traffic simulation
The most accurate way to estimate the required numbers and sizes of transportation facilities is to simulate the People Flow in the station. Some consultants are specialized in providing a simulation service for metro stations. With the KONE Building Traffic Simulator (KONE BTS™), People Flow moving horizontally and vertically can be modeled. Simulation can be visualized by 3-dimensional displays, and People Flow bottlenecks can be illustrated.

KONE BTS has also been used in evacuation studies of metro stations and stadiums. In stadiums, evacuation does not refer to an emergency situation but to the end of the event when all people leave the stadium. With simulation the time that a building or a station can be emptied with the defined number and size of escalators, elevators and staircases is studied. In addition to the egress time, also passenger journey times and waiting time are discovered, as well as the maximum passenger queue lengths and congestion at different locations during the egress.

Figure 17 presents displays of metro station simulation studies with KONE BTS™ and Figure 18 with the Steps program [18]. In Figure 18, different Levels of Service (LOS) are shown in colors. Figure 19 shows a sample output result of an evacuation simulation study with KONE BTS™. A thorough understanding of passenger traffic in a building and interaction between different transports can be found out only by using simulation tools such as KONE BTS™.
4 References
