

# RAMPING UP

## ACCESSIBILITY IN PUBLIC TRANSPORT VEHICLES

### Background

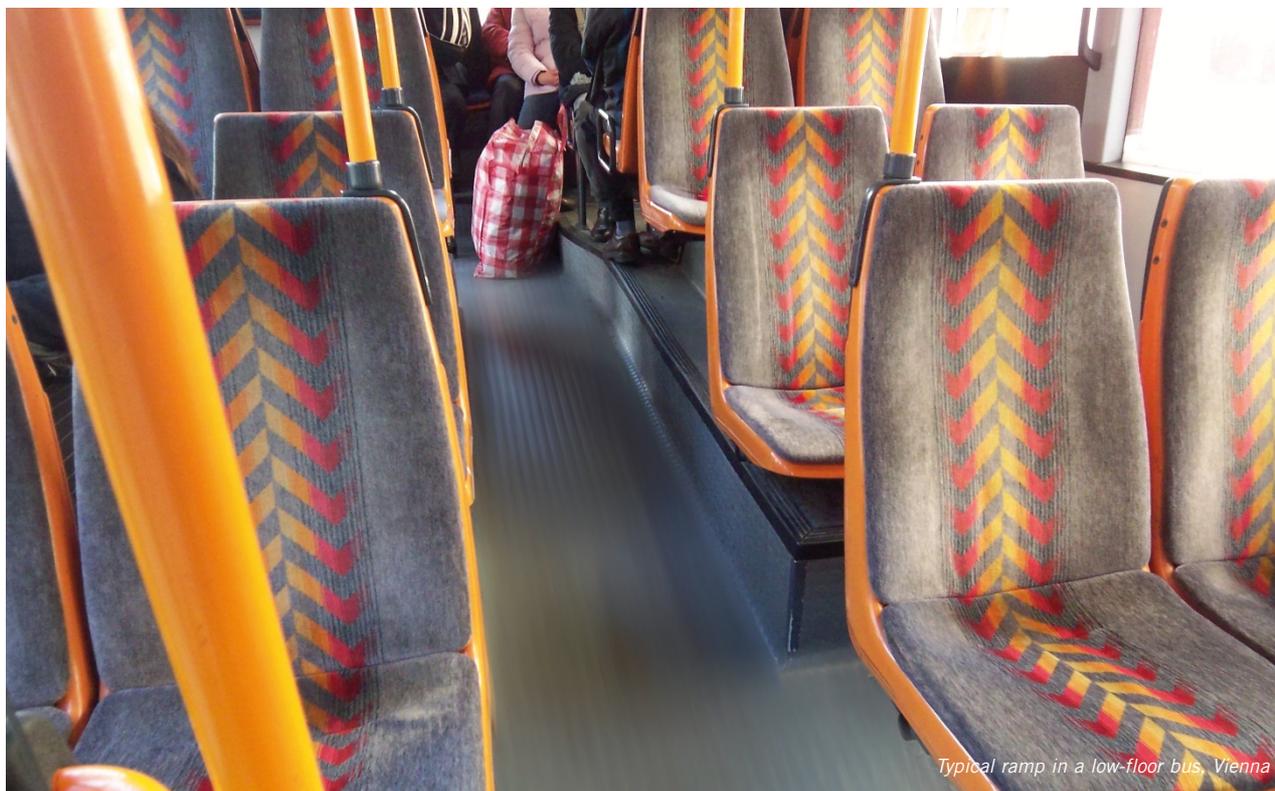
In line with today's efforts to improve accessibility, increasing numbers of transport operators are purchasing low-floor vehicles. In order to allow level access, however, it is often necessary to overcome height differences in the vehicle for construction reasons. This can be achieved by using steps or

ramps. This article aims to raise awareness of the problems and potential dangers that may arise when installing ramps.

### Introduction

For economic as well as technical reasons, low-floor vehicles often do not have completely level passenger areas. As a result, height differences

are often present in the vehicle because of axles, bogies or – as with buses – because of the need to accommodate the engine. They can be overcome using either steps or ramps. Because local transit vehicles are heavily used, particularly during peak times, all uneven points in the floor surface can present a hazard. What are the potential dangers and how can they be overcome?



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Typical ramp in a low-floor bus, Vienna



## Passenger groups

Local urban transport is used by members of all population groups. Users for whom ramps in vehicles may pose particular problems include the elderly and infirm, PRM, the hearing- and visually-impaired. The hearing-impaired often have an impaired sense of balance; the visually-impaired may either be completely blind or have residual sight. Particularly in poor light, people with serious visual impairments are almost blind. And PRM are usually dependent on aids such as walking sticks. In the case of the elderly or infirm, decreasing bodily strength, together with other disabilities mentioned above, play a particularly important role.

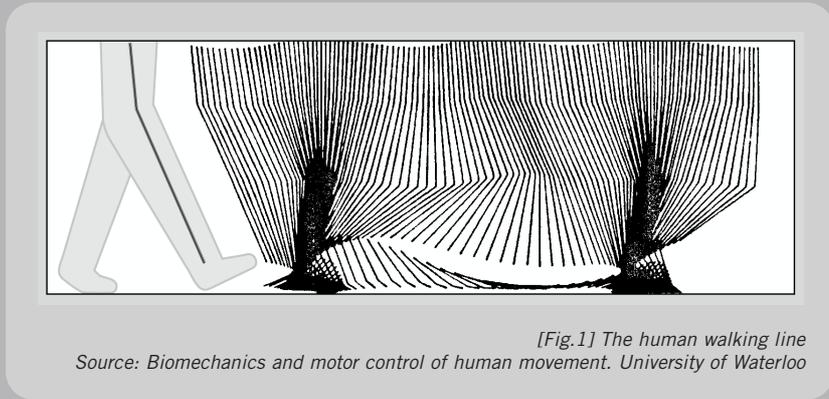
## The potential problem areas of ramps

### Danger of tripping

Ramps are often built with a longitudinal slope of between 6 and 10%. If a person does not see an unexpected slope, they risk tripping. When walking, the movements of the feet are automatically co-ordinated by the human brain. The paths already taken, and their floor configuration, are transferred to the subsequent sequences of steps. Because the human body always tries to expend a minimum amount of energy, the leg is swung only just above the ground when walking to avoid unnecessary elevation and increased energy expenditure. If changes in the floor configuration are detected, the brain reacts by changing the walking behaviour. If a ramp suddenly appears, the leg is automatically lifted higher, for example [see figs 1 & 2].

If, on the other hand, a ramp or some other obstacle is not detected, the leg is swung in the same way as for the previous steps and hits the unexpected raised area. In the case of a downward ramp, this can lead to a person stepping into empty space, which at worst can also lead to injury.

These problems may arise not only when walking in the vehicle, e.g. to reach a seat, but also when passengers are standing



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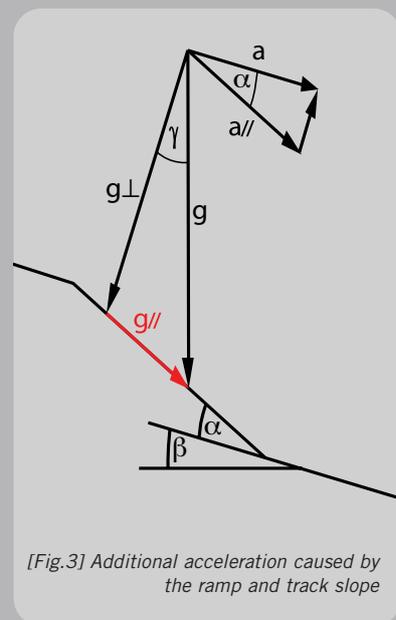
in an adjacent flat area and unexpected acceleration occurs, e.g. during emergency braking. In this case, passengers often take a corrective step to avoid losing balance.

### Occupancy level on the ramp

From an operational point of view, there is also the question of whether sloping areas are used by standing passengers in the same way as flat, or not. From counts taken in buses in Vienna with ramps, it appears that standing passengers behave no differently from the way they behave in vehicles without slopes. This shows that ramps have no adverse effects on the degree of utilisation.

### Additional forces on passengers

From a mechanical point of view, sloping areas mean that forces in a perpendicular direction must be resolved into two components: a vector that is normal to the contact surface and another that is parallel to it. The parallel vector causes additional, longitudinal acceleration [see fig. 3].



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The acceleration that occurs is calculated as follows:

$$a_{add} = g_{ll} \cdot \cos(\alpha + \beta) = g \cdot \sin(\alpha + \beta) \cdot \cos(\alpha + \beta)$$

where  $a_{add}$  = additional acceleration because of the ramp and track slope based on the plane.

The acceleration is calculated approximately using the following formula:

$$a_{add} = g \cdot n[\%]/100$$

where  $\cos \alpha \approx 1$  and  $\sin \alpha \approx \tan \alpha \approx n$  if  $\alpha$  small and  $n$  ... slope in [%].

This means a ramp slope of 10% causes longitudinal acceleration of  $0.1 \cdot g$ , which corresponds to approximately  $1 \text{ m/s}^2$ . If the vehicle is also travelling downhill, longitudinal acceleration on the ramp is combined because of the increased slope. If the road has a 10% slope, acceleration is already  $2 \text{ m/s}^2$ .

In tests in Hanover in 1970, threshold values for passenger perception were calculated for standing passengers.

The acceleration values evaluated by passengers are as follows:

- 0.0 to  $1.3 \text{ m/s}^2$  : inconsequential
- 1.3 to  $1.7 \text{ m/s}^2$  : unpleasant
- 1.7 to  $3.0 \text{ m/s}^2$  : unreasonable
- $> 3.0 \text{ m/s}^2$  : dangerous

When the brakes are applied, situations sometimes occur that fall into the unreasonable or dangerous range because the deceleration values interact with the longitudinal acceleration due to the slopes. Emergency braking, in particular, means the threshold values on the ramp are greatly exceeded.

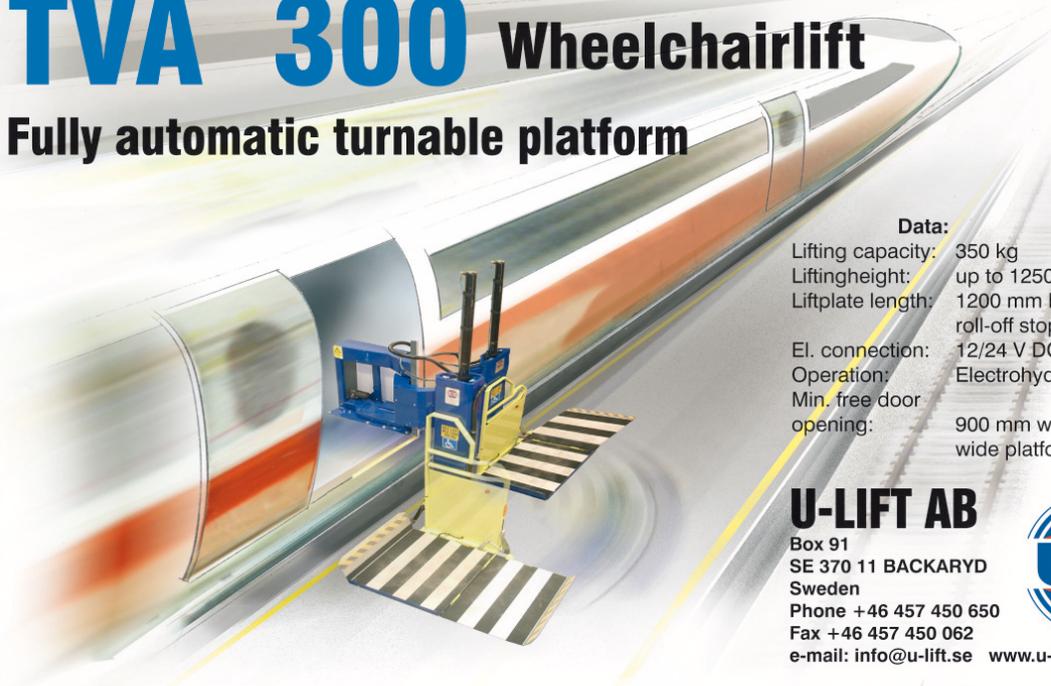
The forces have a particularly strong impact on passengers who are not holding on to some form of support or who are walking on the ramp. As this is normally the case shortly before stops, when passengers are walking towards the exit and the vehicle is braking at the same time, this case arises quite frequently.

#### Operational experiences

Surveys conducted by various transport companies using vehicles with ramps have shown that, while passenger accidents occur time

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## Fully automatic turnable platform



#### Data:

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Operation:	Electrohydraulic
Min. free door opening:	900 mm with 800 mm wide platform

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and again in vehicles as a result of braking, they are not often due to ramps.

**Measures to reduce dangers on ramps**

Steps in vehicles, particularly those with a high proportion of standing passengers, tend to be seen as a more uncomfortable way of overcoming height differences in vehicles, entailing a greater degree of risk. It therefore seems sensible, despite all the reservations and risk areas mentioned above, to link different levels using ramps. However, steps need to be taken to reduce the risks.

It is important to make the ramp clearly visible, particularly the two-angled areas. The marking must be strongly contrasted. Furthermore, there must be sufficient fixtures for passengers to hold on to in the vicinity of ramps.

In low-floor vehicles, ramps are often used to overcome height differences. These ramps have a certain inherent risk potential. The biggest dangers are tripping as a result of not seeing the ramp or as a result of the additional accelerations in the longitudinal direction that always occur on sloping surfaces. The most important remedial measures are proper marking of the ramp's angled areas and additional fixtures for passengers to hold on to. In route networks with a large number of steep sections and increased need for emergency braking, it is important to consider carefully whether vehicles with ramps may still be used.

The operational area of vehicles must also be examined more closely. If the route network includes a large number of areas with greater longitudinal slopes, or if emergency braking frequently occurs, it is important to properly consider whether vehicles with ramps should be used. If vehicles with ramps are already widely in use, the conditions within the network should be changed in certain circumstances. For

example, companies can demand that trams or buses in steeper areas be given their own track, or sections with a separate lane, in order to lessen the risk posed by emergency braking ●

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