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TOWARDS A GLOBAL OBSERVATORY OF PEDESTRIAN FLOW MANAGEMENT LEVERS FOR THE RAILWAY SYSTEM

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Crowd disasters are more and more known and documented, but the ways of preventing them don't follow closely that trend. Train and station operators face an increasing pressure with pedestrian flow management, as ridership often grows more quickly than resources, and cannot rely on a pedestrian flow overview. To help tackling these issues, we launch a global observatory of the current practices and research about pedestrian flow management in stations. This observatory collects, analyses, and synthesises the available information from train and station operators, existing databases, academic and grey literature.

In the literature, some papers and books are already explaining very interesting pedestrian flow management techniques, but no generalized analysis has been made. Several websites are listing crowd disasters and near-miss cases, but they generally don't analyse the causes of the accidents, and they don't offer a panorama of the levers that could be used for preventing disasters or in daily use. Moreover, flow management is not limited to safety and should also enable comfort, accessibility, or railway operation efficiency, which is not broadly covered by these sources. Finally, there is no consensual definition of the capacity of a station, making it difficult to assess the necessity of expansion works.

To address these issues, the observatory collects and shares well-sourced information about crowd and pedestrian flow management, focusing on the case of train stations. That observatory in run is an open-source and collaborative manner, involving railway companies, station managers, and researchers. It aims at providing a complete list of crowd accidents, and a near-complete list of flow managements levers that can be used in the context of train stations.

This paper describes these three tasks of the Observatory: know the risks, collect the solutions, assess the saturation. It also explains how to contribute to this collective effort.

1. RISKS OF TRANSPORT-RELATED CROWD CRUSHES ARE BADLY KNOWN

One of the main reasons to improve pedestrian movement in train stations is safety. In this domain, the bigger risk seems to be the occurrence of a crowd crush (also incorrectly called *stampede*). A crowd crush can lead to dozens, or even hundreds or thousands of deaths, and a similar number of injuries, during a single event. Crowd crushes are not the only crowd-related accidents that can happen in a train station (we can specifically think to the case where a person falls on the track due to the density on the platform), but they might be an important danger. We chose to focus on the

crowd crushes in the early stages of our work, as there were already lists of such events.

1.1 Knowing the history of the crowd crushes

In a first work that we documented in (Dubroca-Voisin, 2023a), we compiled the crowd crushes listed in six different sources (Asgary, 2022; Feliciani et al., 2022, Working with Crowds 2022; Still, 2019; Wikidata contributors, 2023; Wikipedia contributors, 2023). We showed that none of these sources were complete; we then may have a partial view of crowd crushes and miss some important events than happened in transport context. Even partial, our compilation might be the most complete list of crowd crushes in history. We were then able to distinguish crowd crushes that were transport-related.

1.2 A small number of events with no common causes

In a second paper (Dubroca-Voisin, 2023c), we listed the 16 crowd crushes than were transport-related. Most of these events happened in train stations; some of them were linked to war events or public gatherings, but some others happened during normal train service operations. The five more recent events all happened in Indian stations (that could be linked to the growing pedestrian flows in the country but also to its better anglophone press coverage).

For each of these events, we analysed the potential causes. This work was based on press coverage, which can be very incomplete, therefore this analysis cannot be a scientific approach to these events. However, we can observe that it is very difficult to find common causes to these events: overcrowding generally played a role but the succession of events leading to a transport-related crowd crush is very variable. Simultaneity of trains also seems to have a growing role in the occurrence of such events.

1.3 Future work

Our work showed that crowd crushes did happen in the (recent) past in train stations: this confirms they are definitely not risk-exempt. Therefore, we think it's needed to keep investigating those cases: run extensive analyses of past events but also gather information on near-misses cases. In the meantime, we plan to assess both the safety impact of situations other than crowd crushes, and the non-safety aspect of crowd-related accidents (economical and image impacts, for instance).

To improve the reliability of the crowd crushes list in the future, we also propose the collective use of Wikidata. The website organises data in a semantic way and also offers powerful exports tools, making easy to visualise data (Figure 1).



Figure 1: cartography of crowd crushes listed on Wikidata, September 2023.

2. THERE IS A HUGE OPPORTUNITY IN BETTER KNOWING THE LEVERS

By pedestrian flow lever, we understand a management measure that can be implemented with reasonable means and aiming at a substantial effect. Using these levers, station managers can improve how the pedestrian flow works in the station without burning down all their available resources. They might be powerful tools, but they're insufficiently known. Only a few research papers and books, such as (Campanella et al., 2015; Feliciani et al., 2022; King et al., 2014; Moroni, 2022; Muñoz et al., 2018), describe the levers that can be used in a transport-related context. The second part of the Observatory is then to collect as much precise information as possible on the existing implementations. To do so, we propose to use a basic questionnaire but also a detailed analysis grid. Results are made publicly available on the Observatory website (temporarily at the address mind-the-cap.github.io).

2.1 How to analyse a lever

To fully understand how a lever works, we propose to use a detailed template (Dubroca-Voisin, 2023b). We divided it in several parts:

- Description of the lever (situation, operation and effects, activation and classification), to be able to understand how the lever is operated (by who and in which conditions, notably) and what place it takes in the station but also in the traveller's journey. Classification offers a first occasion to compare the levers by assessing them on different axes: physical vs virtual, influence vs coercion, easiness of activation, cost, and permanence.
- Description of the station itself, to better understand the transport, mobility and urban context of the lever, but also the stakeholders and their interactions.


- Analysis of the lever (cost, gain, measure of performance, impact on risks). This section can include an analysis that has been made specifically when filling the template if the existing measures are not sufficient.
- Historic of the lever (decision of implementation, first steps, adaptations and acceptance), to describe the *story-behind-the-lever*, that can be full of learning experience.
- Replicability (similar implementations planned or done, expected ability to implement this lever in a different context).

All these topics might need a long analysis time, but we're convinced it is needed to encourage the future dissemination of these levers. However, an alternative is to fill a shorter questionnaire that's available on the Observatory website; it covers mostly the same themes and still helps to understand how a lever works.

2.2 Presentation of levers

Once they're obtained, these results are presented on the Observatory website. Figures 2 and 3 show the first presentation choices that were; the first on a lever already evaluated by the literature, the second on a lever that was observed directly. This presentation may change to include more details and be clearer.

Dividing a metro platform by an unidirectional gate

 Tobalaba metro - Santiago (Chile)

A gate in the middle of the platform nudges the passengers to use the rear carriages, and forces those at the front of the train to use a longer path. This reduces the congestion in the stairs and then at the rear of the platform. This lever is only activated at peak hours, with staff involved.

€€€€€ Unknown ROI
Station capacity +15 %
Travel time -5 %

Physical	<input type="radio"/>	Virtual
Influence	<input checked="" type="radio"/>	Coercion
Activable	<input type="radio"/>	Permanent

Platform

Sources
Muñoz, J. C., Soza-Parra, J., Didier, A., & Silva, C. (2018). Alleviating a subway bottleneck through a platform gate. *Transportation Research Part A: Policy and Practice*, 116, 446-455.
<https://doi.org/10.1016/j.tra.2018.07.004>



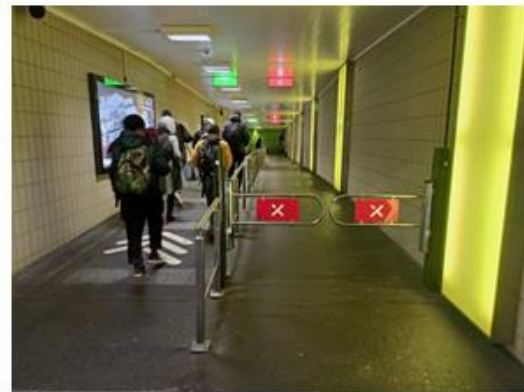



Figure 2: First version of the presentation

Separating flow and counterflow by a barrier in a corridor

Lausanne station (Switzerland)

The barrier is installed in the underpass between the metro station of Lausanne station and the station herself. It looks permanently activated, however it is mainly useful when massive flows come from the metro station, when trains end their southbound journey on the northbound platform, causing a massive counterflow. Using a barrier helps to separate the flow in two and avoids any blockage. Gates at the end of each corridor part ensure unidirectional flows.



€ €€€€

Unknown ROI

Efficiency not measured

Apparently accepted



Physical Virtual
Influence Coercion
Activable Permanent

Corridor

Sources

Direct observation, 30/11/2022

Figure 3: second version of the presentation

2.3 Future work

The primary goal is to include more and more levers to the collection. We could then compare the efficiency of these levers in different contexts. An additional possibility could be to collect levers that are not used in the railway system but in different spaces (such as museums, stadiums, public space...); these levers could potentially be adapted to the railway context.

3. ASSESSING THE SATURATION

In a third part of the Observation, we plan to observe the saturation of stations and their different elements. This is currently the less advanced part of the work; a first

method has been drafted and should be published soon. One key indicator will obviously be density in the station, but other indicators such as percentage of time under desired speed, number of quality journey choices within the station, or economic indicators will also be considered. For this work, we aim to only use publicly available data (such as the open data published by SNCF and other operators).

4. CONCLUSION

With this Observatory, our goal is to share knowledge about pedestrian flow management in the railway system, a task that is mainly done in stations (but not only). Knowing the past crowd crushes and crowd accidents should help to evaluate and anticipate the risk. Being able to determine which management lever is effective in different contexts may help to disseminate these solutions in the railway context. Finally, having an overview of the saturation situation would help to prioritise the actions and the investments.

We hope that we will find a diversity of contributions to reach these goals.

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