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RESEARCH ARTICLE OPEN ACCESS

People Flow in Trains and Stations

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I. INTRODUCTION

Soon after its invention, the train has become one of the essential means of transport and continues to be so today. Train cars, station concourses, platforms and other components constitute major parts of the passenger experience.

The flow of people through stations, into trains and out thereof poses a challenge to matters of safety and promptness. It is an issue worthy of research and should not be overlooked.

This literature review looks at the similarities and differences between railway trains and metro and light rail trains. It then inspects modelling and tracking of people movement. Next, it glances at the time problem. The design of station and train comes after that. The handicap problem and emergency situations follow. Old vs. new research concludes the paper.

II. LITERATURE REVIEW

It is beneficial firstly to look at components of the train-station system that affect people flow (in no particular order):

- Entry/exit to stations
- Security checkpoints
- Concourses
- Ticket vending machines
- Ticket collection machines
- Ticket and information windows
- ATMs/vending machines
- Turnstiles
- Stairs
- Escalators
- Moving walkways (conveyors)
- Lifts
- Restrooms (toilets)
- Drinking water fountains
- Restaurants/cafes/shops
- Merchandise booths
- Platforms
- Doors to trains (with gaps)
- Refurbishment/cleaning barriers
- Digital display boards
- Direction signs
- Pillars
- Waste bins
- Audio system (public announcement)
- Emergency equipment available to passengers and/or staff
- Passages and pedestrian bridges
- Rows of seats/chairs
- Performers (musicians, etc.)
- Beggars

These components may alter people's walking speed or direction. They can break large groups into smaller ones, create disturbances around them and affect the flow, most probably in a negative way. System management is encouraged to see whether any of these components can be better designed to become flow-friendly.

Factors affecting people flow are:

- Pressure from the passengers behind
- Individual desire
- Luggage
- Preoccupation with personal devices
- Language barrier
- Culture
- Upbringing
- Reduced Mibility
- Period of day
- Health status/intoxication

RAILWAY TRAINS VS. METRO AND LIGHT RAIL TRAINS

The literature does differentiate between types of transit trains in each problem statement and solution. Although this study is related to railway trains and stations, the metro and the light rail can be beneficial in drawing comparisons and learning from some of their aspects.

One the main differences between railway trains and the other two is that the passengers do not plan their arrival to metro and light rail stations but arrive randomly.

S. Li et al [1] made an attempt to model the "stochastic" passenger flow when arriving to metro stations. Recovering train delays and preventing the instability of metro operation especially at unpredictable disturbances are the aims for their regulation.

It is a known fact that rail services became a "viable alternative" to other modes of travel, especially cars, because of the "increasing highway traffic that causes congestion," as reported by J. Li [2].

On the other hand, many aspects of train systems are similar. They are all means of mass transport, as opposed to cars. Another similarity is that people go to and through stations before reaching the train. Stations differ from one type of transit to the other but do have similarities; the most obvious is that they are all places for people to gather (sometimes overwhelmingly) and wait for their ride.

The literature, however, addresses either railway train stations or metro stations. Papers do not mix them and it appears as if they are addressing only one type of transit at a time.

MODELLING/TRACKING PEOPLE MOVEMENT

It is widely expected that people who are familiar with a facility take less time making use of it. People who step in a facility for the first time, however, will take a longer duration to use its components efficiently.

This becomes evident in times of maintenance to parts of the station. The station's layout changes due to the presence of unusable spaces. Shifts of previouslyknown motion paths become obligatory, increasing "passenger travel time and frustration" [2].

As for tracking people, it should not be thought to mean tracking certain persons as in a security or crime-fighting setting. It means tracking the movement of people to evaluate walking speed, direction, barrier avoidance and the like to better understand design considerations of trains and stations. Prassler et al. [3] demonstrated this using laser rangefinders installed in train stations. The devices tracked the direction and speed of people movement. See Fig. (1).

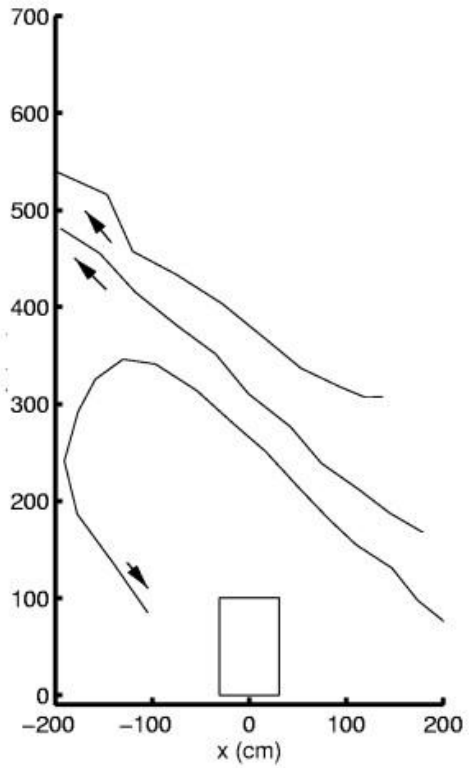

Figure 1 - One example of people-tracking using laser rangefinders [3].

Another type of laser equipment, namely laser scanners, was used by Nakamura et al. [4] to analyse human behaviour for "moving trajectories, walking speeds and retention patterns" using data obtained from the equipment. This research was done in three train stations, all in Tokyo, which highlights the cultural factor, causing the research to be disadvantaged.

Most research papers are prone to this limitation.

"The process of alighting and boarding [a train] is somewhat chaotic" say Zhang et al. [5], therefore, many factors should be expected to affect this process. This was a modelling and simulation study made in several metro stations in Beijing (the culture factor again) in which individual and collective group behaviour was examined.

"The modelled passengers appear to exhibit reasonable intelligence and diversity during the process of alighting and boarding."

THE TIME PROBLEM

People are not robots programmed to move in an optimal fashion. There are human and

other factors influencing their behaviour and flow that can lead to delays in any or all of the train boarding and alighting process stages.

Nevertheless, preserving the train's schedule and maintaining promptness is very important to the operation of the whole system.

Disruptions and blockages in the metro service can lead to passenger accumulation in stations. This is not a major problem in itself. People can choose either to wait for trains after the disruption ends or to exit the station provided they get their money back.

Nonetheless, Gao et al. [6] showed that rescheduling the metro line and following a *skip-stoppattern* would eventually "reduce the number of stranded passengers faster and reduce the passengers' total waiting time more effectively." It is worthy of note that, in that research, the possibility of passengers leaving the stations was ignored.

In railway trains, D. Li et al. [7] tried to estimate train dwell time at "short stops."

It can be easily shown that the dwell time at these short stops depends on many factors but primarily on the number of passengers alighting and boarding the train. In the railway context, the train operator normally knows in advance the number of passengers alighting and boarding the train at each stop, but not prior to train dispatch by a very long time. This affects the operator's ability to accurately determine the total train travel time beforehand.

DESIGNOF STATION AND TRAIN

Oh et al. [8] made a laboratory experiment followed by a live observation of the effect that the train door width has on the flow of passengers. The researchers found "no significant difference between the two approaches," namely, the lab experiment and the live observation. An increase in door width "can be quite useful in reducing passenger flow time."

Many other design considerations exist to better people flow. Increasing platform width and reducing the horizontal and vertical gap between the train and the platform are examples of measures that enhance people flow.

PERSONS WITH REDUCED MOBILITY

Persons with Reduced Mobility (PRM) should be able to travel with relative ease and dignity. Means of mass transportation need to become more handicap-friendly and more research should be made in this field. It causes me discomfort not to have found research related to PRMs in trains and stations.

The technological advances in many aspects of our lives must be directed toward enhancing the lives of the handicapped as well as those of regular people.

EMERGENCY SITUATIONS

Handling emergency situations and incidents is vital to the safety of people and equipment. The train system management must be certain that all people and things under its supervision are safe at all times and situations.

The incidents meant here are inadvertent incidents.

One experiment made a planned evacuation of a metro train in a tunnel. Fridolf et al. [9] recruited a number of people, filled a train with them and made an "emergency" stop in the tunnel. Under guidance, the volunteers had to exit the train by hopping to the ground, walking some distance on uneven ground, and exiting the tunnel through one of the emergency exits.

Although beneficial, this experiment was far from any real emergency. The volunteers, though untold of what exactly was about to happen, signed up for the experiment on the presumed assumption that 'something' was going to happen. In a real emergency, people will be attacked by surprise and this will add to the hardship not present in any experiment. In a real emergency, there will be a threat to life or wellbeing such as fire or explosion. Nothing of the like was present in the experiment. Additionally, walking in the lit tunnel, although not entirely pleasant, was reasonably safe and did not involve smoke or heat from fire.

OLDVS. NEW RESEARCH

The oldest paper retrieved for this review was written in 1958 for the London Subway and was an attempt to understand the flow of people through subways and stairs [10].

Although 95 years had already passed since the establishment of the London

Underground, the '58 study was one of the first endeavours to model people flow in the tube.

Over-crowded and aging, the stations had long reached their maximum capacity. New facilities were thought to be in need of a new design that avoids the old stations' shortcomings and house a greater number of users.

Not able to employ average station-goers to model the flow, Hankin and Wright resorted to schoolboys (through the cooperation of a school's headmaster) and made the peopleflow modelling by making a large number of boys walk through a ring defined by palings held by other boys on a paved surface. See Fig. (2).

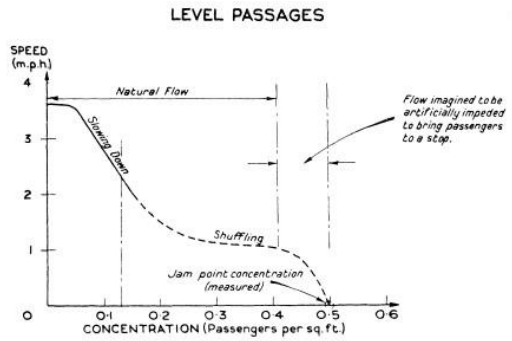

Figure 2 - Speed-Concentration Diagram for schoolboys [9].

Although this method was extended and the results confirmed in the actual London Subway by observing adult users of the station, the idea of using schoolboys to mimic the general public does not come close to doing that. Children tend to walk in a different speed to that of adults: slower in some cases, faster in others.

Flow of people is the number of passengers per foot-width per minute. Concentration of people is their number per unit area (square foot). These definitions were used by Hankin and Wright.

The rest of the literature retrieved is mostly new. Five articles (out of eleven references) were published in 2016. This proves that this is a 'hot' topic for research and future designs will be influenced by such research.

In Patent "Subway passenger loading control system" by Chun and Lee [11], the inventors aimed to devise a system capable of functioning "in its most efficient passenger handling manner and keeping all transporters operating on the pre-established time schedule."

Although the patent claims to enhance the efficiency of the passenger handling system, it is yet to be implemented to explore its full potential.

III. CONCLUSION

The issue of people flow in trains and stations acquired the attention of many researchers, each of whom dealt with a different aspect of the matter.

Many researchers fell into the culture gap and modelled the flow of people in one locality only. People in a certain country all act more or less in the same manner and caution should be exercised when applying research based on people behaviour in one locality to another.

While it is understood that the truly international study is out of reach or at least very difficult, it would have been beneficial to the literature to make the research for each paper in at least more than one country, especially by researchers funded by cross-country train operators. Peak and off-peak times were distinguished properly. Some papers specialised in rushhour traffic [3], [6]. The peak times are defined as early morning hours (when people ride the trains to work) and evening hours (when they get back home).

Most articles differentiated between weekdays and weekends. The pattern of people travel is evidently changing between these periods.

Papers that tried tomodelpeople's behaviour fell in the trap of discrepancies. Schoolboys were used to model the motion of adults and a selected group of people were used to model the accident behaviour for otherwise unsuspecting riders.

If a near-real experiment is not possible, it should be brought, as nearly as possible, to reality.

It should also be kept in mind that a real-life group of people undergoing an incident in the tunnel, for example, may contain people with limited mobility, people who may not help others or people who may use the situation contrary to the best interest of the whole group.

In situations where there are no clear guidelines and no clear leader, people flow will be impeded by personal habits. Some of these are not the best habits.

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