# Lessons learned and consequences from the Love Parade Disaster Duisburg 2010 – Technical Guidelines for Traffic Management and Crowd Management as an integrated system

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***Abstract***

*The tragic events at the Love Parade Duisburg 2010 with 21 deaths and over 650 injured was terrible and drastic for planning, licensing and acceptance processes as well as for the implementation of events. The 3,800-page court report written by the co-author and his team shows that deficiencies in the planning and licensing of facilities and offerings at the event, a lack of coordination of processes and an insufficient transfer of information were among the causes. Essentially, the event site was not suitable for the event management concept and for the expected and actual crowd flows. The unsuitability was not recognised in the run-up to the event. The results show once again how important it is to plan carefully, in a coordinated manner and without gaps. At the time of planning, there was a lack of guidelines or regulations dealing with traffic and crowd management in the regular operation of an event. It is important to carefully prepare the overall system consisting of road infrastructure, public transport stops, car parks, paths, waiting areas at entrances, entry controls, tunnels and ramps as well as public spaces for the expected flows in advance, to keep an eye on the entire system with its interactions during the event and to jointly decide on measures if hazards arise in parts of this overall system. The technical regulation now available from the Road and Transportation Research Association (FGSV) entitled "Recommendations for traffic and crowd management at events" is trend setting and shows that planning for and managing crowds includes many tasks from the field of traffic planning and traffic management and is correctly located there. The work is attracting international attention. It will significantly influence the planning and implementation processes as well as the existing and established education and training programmes for event planning and management.*

## 1. Causes of deaths and injuries in crowd flows

On 24 July 2010, the world's largest techno music festival, the "Love Parade", took place in Duisburg, a city in the west of North Rhine-Westphalia. Around 500,000 spectators were expected to attend the event. At around 4:30 p.m., crowds of people thronged a sloping ramp of the venue, it became increasingly crowded, many people fell to the ground and were wedged into each other. Within a very short time, 21 people were killed and over 650 people were injured.

The main goal of the trial on the Love Parade Duisburg was to clarify the causes of the tragic events. Even though the trial was not brought to a complete legal conclusion, the causes

could be comprehensibly illustrated by an expert assessment written by the co-author, Juergen Gerlach. A professional illustration of the court report summarises the causes [1].

Events like in Duisburg 2010 or also during Halloween in Itaewon, Seoul 2022 show that it is very important to adequately plan for and manage crowds. The terrible events in Duisburg 2010 and in Seoul 2022 have similarities. The fact that in Seoul there were high walls to the left and right, narrow spaces in the middle and only a few exits on the sloping street were similar. The Love Parade disaster occurred on a sloping ramp about 20 m wide and about 100 m long (Figure 1). The Itaewon disaster occurred when people poured into a sloping alley 3.20 m wide and 40 m long near the Hamilton Hotel (Figure 2). In general, there is a high risk when many people stumble in a delineated and then narrow situation.

Figure 1: Snapshot of the ramp at the Love Parade location in Duisburg at 4:25 pm - opposing streams were blocked on the ramp [2, Extract Minute 59:00].

Figure 2: Downhill alley where the Itaewon disaster occurred, Source: https://kbizoom.com/it-is-difficult-to-pin-who-is-responsible-for-the-itaewon-disasterpeople-were-being-too-complacent/

Mass disasters usually occur when crowd flows or gatherings of people become very crowded. This can happen when crowd flows cross or meet in more than one direction. Even when the crowd is moving in one direction, congestion can occur with serious consequences if the path narrows. In a congestion, crowding can occur when people are highly motivated. In this crowd, there are different phenomena that are associated with life-threatening risks. These are fainting due to shortness of breath, wave movements of the crowd and loss of balance. If various people fall to the ground in this situation, stacks of wedged bodies can form [4].

Congestion in pedestrian traffic can cause hazards, especially when travelling to, but also when departing from and being present in audience areas. The situation in a crowd cannot be determined solely by parameters such as the average pedestrian density on a larger space or the average speed on a cross section. Rather, the determining factors are situations in small clusters of people, which can lead to dangerous conditions in as few as four or five rows of people - depending on the mood and motivation of the people in this cluster. One of the reasons is that communication is no longer possible across this number of rows. There is a lack of "front-to-back communication". In this respect, it is not decisive for any pressure to which a person in a crowd may be exposed whether, for example, 100 or 10,000 people are in a crowded situation. Rather, the crowd density as well as the moods and motivations of the people in the respective cluster are decisive.

High crowd densities, strong motivations and a lack of information can trigger tragic events. Careful preparation and planning is necessary in order to exclude such situations as far as possible. The court report on the Love Parade Duisburg, for example, points out that on the day of the event, the actors had few if any options left to prevent terrible events [1]. The main problem was rather that the site was not suitable for the event management concept

and for the expected and actual crowd flows in and out of the event area. Three areas - the two entries and the top of the access ramp - were far too narrow. Congestion was to be expected at all three points. These congestions also occurred very early on shortly after the site opened. They were the trigger for the events on the day of the event. What is serious is that the unsuitability was not recognised in the run-up to the event. It is also serious that at the time of planning there were no requirements and rules of technology that could have been used to check the suitability of a site for regular operation.

At the time of the planning and realisation of the Love Parade in 2010, there was a widespread lack of technical rules that comprehensively dealt with the planning and management of crowd flows and that were introduced in a binding manner as far as possible. The traffic and crowd management of events is only dealt with in a very incomplete manner in existing laws, regulations or standards worldwide. What is primarily regulated is emergency management for events and hazards outside regular operations. To date, this seems to be the case in many countries around the world.

## 2. Publication of regulations on traffic and crowd management as a consequence of the events at the Love Parade Duisburg

After the disaster, the Road and Transportation Research Association (FGSV), which is authorised to draw up regulations and guidelines in Germany, took measures to prevent a recurrence. After the findings from the Love Parade trial became available in 2020, the FGSV published a set of regulations for the planning, licensing and implementation of events, the so-called "Recommendations on traffic and crowd management for events (EVC)" [3]. The regulations include, among other things, how many people can gather in a certain area and how to plan such a crowd in advance in order to prevent dangerous situations from arising in the first place. Crowding is defined as any occasion where several or many people come together. This can include different types and locations of events, such as village and city fairs, country festivals, markets, outdoor events as well as indoor events, halls and stadiums, or demonstrations and other circumstances with potentially confined situations, e.g. on railway platforms.

Even now, the committee and the associated working groups are active to develop further in-depth regulations on the topics of

- Use of simulations in planning for and managing crowds,
- Recognise and respond to critical situations at events and crowds,
- Design, dimensioning and operation of public spaces in the surrounding areas of event areas and gatherings of people

to be published. Technical rules show how such disasters can be prevented.

In this context, the lessons learned from the Love Parade 2010 show that careful planning with adequate design, dimensioning and allocation of responsibilities in the run-up to the event, as well as good crowd coordination and management on the day of the event are essential. Above all, the security of the event must be carefully prepared and planned months in advance. Detailed consideration should be given to whether a site is suitable for a forecast of arrivals, attendance and departures and the resulting expected crowd flows and crowds in various areas. It makes sense to create several scenarios that define various measures as well as the responsibility for each action in detail and clearly in advance. It may

be necessary to restrict access to places with limited spaces and special attractions, while extensive spaces can remain freely accessible. One possibility is to control access to a limited space and before too many people gather, for example, to allocate free tickets online in advance and inform people in advance about the restrictions.

Situations involving personal injury can sometimes not be described by objective, measurable factors alone, but also by the subjective assessment of the situation of people in a cluster of people and the subsequent reactions. For example, during the Love Parade 2010, people were initially standing on the ramp in a congestion with crowds. Then, visibly for many people, three paths opened up onto the event area - a narrow staircase, a light pole and a container. At first, it was a matter of not missing an expected event. This was followed by a push towards these three points. Only then did many people realise that the situation had become life threatening. The perception of an immediate and serious danger thus occurred temporally after the urge had arisen. A consequence of this perception and the pushing to the three points were then wave movements that led to stumbling and stacks of wedged bodies in various clusters of people [3].

Studies have shown that, in addition to a lack of coordination of procedures, insufficient dissemination of information is one of the most frequent causes in connection with accidents at events. Lack of information can both trigger situations (e.g. by pushing or fleeing) and aggravate an already problematic situation [3].

One goal of careful preparation and planning must be to create forgiving structures as well as structures that can tolerate or compensate for deviations - through corresponding space planning but also, in particular, through the interaction of space design and personnel or organisational measures to guide and direct the people in the respective space.

Such measures must be prepared in detail. Regulations are ideally suited to provide assistance in this regard. In addition, they introduce measures for adequate planning and the safest possible implementation of an event in a largely binding manner.

## 3. Structure and content of the Recommendations on traffic and crowd management for events

### 3.1 Overview of the regulations

The regulations on traffic and crowd management for events are the result of voluntary work by experts in event planning and implementation. The contents are based on numerous proven research findings, evaluations and existing experiences at events. The regulations contain requirements, standards and opportunities for action for consideration in the planning, approval processes and implementation of events that have not been available in this form before.

Traffic and crowd management includes the planning, licensing and operation of facilities and offerings,

- the handling of flows of people or traffic,
- on the journey to and from the audience areas as well as
- the movement of people and crowds in audience areas of an event
- during regular operation and in the event of incidents or hazards

serve.

The regulations are to be used in all planning and approval processes dealing with traffic and crowd flows to and from events, as well as in the management and assessment of crowd flows during the course of events. These can be planning processes in the run-up to an event or a gathering of people as well as control measures during the operation of the event, including the time for arrival and departure. Over 100 pictures and many examples illustrate the topic and facilitate its application. The implementation of the instructions for action ensures the safest, most efficient and most compatible handling of traffic and people.

The focus is on traffic management and crowd management as a joint task of the organiser and the public administration. The recommendations present recognised rules of technology as well as the state of the art for traffic planning processes and crowd management at events, and they take into account the tasks of planning, guiding and controlling people arriving, departing and attending. In particular, the requirements for event safety, public safety and order, traffic quality and comfort, environmental compatibility and safeguarding the interests of the general public are dealt with.

## 3.2 Binding nature of the regulations

It is important to know that such a publication by the Road and Transportation Research Association is regarded and used in disputes and trials in Germany as recognised rules of technology or as the state of the art. In this respect, it is recommended that the regulations be carefully applied in all planning and implementation of events and in preparations for gatherings of people. The regulations include

- Requirements and demands ("it is/it must/it must not"),
- Standards and rule cases ("it should/it should not"),
- Options for action (it can/it could).

Requirements result from safety-relevant and functional basic requirements as well as from the implementation of legal framework conditions. Standards and use cases are derived from documented and verifiable findings and ensure appropriate quality requirements. They reflect experiences that apply to most use cases. Options for action are only appropriate in certain cases that are pointed out.

It is advisable not to deviate from requirements and specifications, or only if absolutely necessary, and only to deviate from standards and rules for good reasons, and to justify these deviations in writing - preferably in the safety concept for an event. If this is not observed, a breach of recognised rules of technology can be alleged in the event of damage and legal action.

## 3.3 Contents of the regulations

The basis of the analysis is the spectators' journey to and from the venue. This "customer's journey" is a central element of the event experience from the user's point of view. Aspects of managing the movement and accumulation of people in the audience areas as well as the possible evacuation of an event site in case of emergency also play an important role.

The regulations have a modular structure. Depending on the event and its relevance, all aspects of traffic and crowd management or only various modules can be applied. The following are considered

- Road traffic facilities, squares and paths,
- Facilities for parking motor vehicle traffic,
- Public transport services and coach and taxi services that support travel to and from the destination as part of the public transport service or as special services,
- Cycling facilities and bicycle parking facilities,
- Walking facilities such as sidewalks and paths including tunnels, access points and stairs leading to and from the audience areas of an event,
- Entrances and ingress control systems such as doors, gates, line-up gates of ingress control systems and ingress control points including upstream queuing systems or upstream areas for pulse formation,
- Audience areas used by standing or moving persons as central event areas, such as rooms and halls or outdoor areas with seating and standing areas, dance floors, paths between exhibition and amusement facilities or paths between market stalls,
- Facilities and services that serve to guide and direct arrivals and departures, such as information services, signposting systems, traffic control centres and steward services,
- Facilities and offerings provided for the orderly assembly and movement of people in audience areas, such as order and security services or barriers,
- Exits in the course of footpath stages of departure as well as
- Emergency exits to ensure evacuation in case of emergency.

The modules deal with individual topics that may be relevant in the context of planning, licensing and implementing events:

- Module 1: Legal basics on traffic and crowd management for events,
- Module 2: Determination, estimation and influencing of traffic flow and flow rates at events for the different traffic modes,
- Module 3: Handling of moving and parking motor vehicle traffic, its signposting and traffic management, provision and organisation of parking facilities and special traffic (logistics, delivery traffic, emergency services),
- Module 4: Provision and organisation of public transport (PT) and any shuttle services and handling of coach and taxi traffic,
- Module 5: Management of cycling and provision of bicycle parking facilities,
- Module 6: Planning the handling of the flow rates on footpath stages to and from the audience areas and managing the movements and accumulations on the audience areas,
- Module 7: Monitoring, assessing and managing crowds during an event,
- Module 8: Management of incidents and hazardous events,
- Additional module 9: Checklists and to-do lists,
- Additional module 10: Numerous practical examples.

In the following, some excerpts from various modules are presented. It should be noted that in particular the interactions between the various traffic management and crowd

management aspects can also play an important role. For example, it can make sense to fill parking facilities in such a way that paths between parking spaces and audience areas are not congested. If planning shows that congestion cannot be ruled out at bottlenecks, for example, certain public transport stops could be served in such a way that crowd flows can be equalised.

Module 1 shows that at the beginning of the planning of an event, both on the organiser's side and on the official side, a coordinating body should clarify the question of the various responsibilities and coordinate the planning or licensing and implementation of the event. The various steps of the procedure up to the implementation of the event are shown. It is also recommended to document all results achieved after the event or to archive existing documents and evaluations so that they can be retrieved at a later date.

Module 2 provides standards and recommendations for the preparation of a forecast of the number of arriving, departing and attending people at time intervals. Common time intervals t are 60, 30, and 15 minutes, with sizing, design and review of road facilities based on the peak hour and walking facilities based on the highest rate loaded 2-minute interval. For large and prolonged events, such as daytime events with multiple timed attractions, forecasts of expected arriving, departing and attending people are usually based on hourly values. For events with one attraction and with arrival and departure phases of shorter duration, forecasts in 30- or 15-minute intervals are more suitable. Table 1 shows an example of such a forecast.

| **Time** | **q30**, arriving<br>**Arriving persons in the time interval via the entrances** | **q30**, departing<br>**Departing persons in the time interval via the exits** | **q30**, attendance<br>**Attendance at the end of the time interval in the audience areas** |
|---|---|---|---|
| **13:00 - 13:30** | 5.000 | 0 | 5.000 |
| **13:31 - 14:00** | 5.000 | 0 | 10.000 |
| **14:01 - 14:30** | 10.000 | 0 | 20.000 |
| **14:31 - 15:00** | 25.000 | 0 | 35.000 |
| **15:01 - 15:30** | 10.000 | 0 | 45.000 |
| **15:31 - 16:00** | 5.000 | 0 | 50.000 |
| **16:01 - 16:30** | 0 | 0 | 50.000 |
| **16:31 - 17:00** | 0 | 0 | 50.000 |
| **17:01 - 17:30** | 0 | 5.000 | 45.000 |
| **17:30 - 18:00** | 0 | 35.000 | 10.000 |
| **18:01 - 18:30** | 0 | 10.000 | 0 |

Table 1: Exemplary estimation of arriving, departing and attending persons at a sporting event [3].

Recommendations for estimating passenger volumes, typical hydrographs and estimates as well as possibilities for influencing the modal split on the various modes of transport are listed.

Module 3 deals with vehicle traffic and parking. It includes guidance on how to allocate the expected vehicle traffic to arrival and departure routes. The goal must be that all people arriving can be in the audience areas at the time when their expected experience begins. Congestion in flowing traffic or lost time before parking is cleared can usually be accepted to the extent that this goal can still be achieved. Procedures are given with which the achievement of the goal can be checked. In addition to manual calculation methods, the use of micro-simulations is also possible (Figure 3). If deficits are identified, traffic regulation and traffic management measures are to be prepared, which are described in detail in Module 3.

Figure 3: Example of a microsimulation of travel to and from the audience areas of an event.

Information on parking management concerns the determination of parking space requirements, the dimensioning and design of the parking space supply as well as the entrances and exits to and from the parking areas, including handling and control. This includes cashiering by staff, the use of a credit, debit, credit or authorisation card, control media such as parking chips, magnetic strip or barcode tickets. Procedures are listed that allow an estimation of waiting times and congestion lengths depending on the expected traffic load and the system-specific capacity utilisation (Table 2). Special traffic such as police, ambulance and rescue services, VIPs, delivery traffic, arrival traffic of showmen, staff, people with disabilities and special parking privileges as well as the protection of residents are also dealt with.

| Control medium | Entry | | |
|---|---|---|---|
| | Handling time [s] | | |
| | Individual vehicles | Follow-on vehicles | Capacity [private cars/h] |
| Credit/Debit Cards | 24,40 | 21,60 | 160 |
| Credit/customer cards | 16,40 | 16,70 | 210 |
| Hand cashing | 17,80 | 14,90 | 240 |
| Chip card tickets | 10,90 | 10,40 | 340 |
| Magnetic strip/barcode tickets/chipcoins | 13,30 | 12,30 | 290 |
| Magnetic stripe tickets (side position) | 13,30 | 12,30 | 290 |

Table 2: System-specific capacities at entrances to parking areas [3].

Module 4 deals with the provision and organisation of public transport as well as possible shuttle services and the handling of coach and taxi traffic. In general, a high share of public transport in the total traffic volume should be aimed for at events in order to ensure environmentally friendly and compatible travel to and from the event. Public transport requires significantly less space per person than motor vehicles, so that a high public transport share can significantly reduce the required infrastructure for moving and parking motor vehicle traffic. The module contains numerous recommendations on how to achieve a high public transport share and a demand-oriented and largely barrier-free public transport offer as well as a low disruption public transport operation. Among other things, exemplary capacities for regular services are given (Table 3).

| Vehicles used in public transport | Journey sequence time in cycle minutes | Typical capacity of a public transport line per direction |
|---|---|---|
| Midibuses, e.g. 45 seated and standing passengers | 30 minutes | approx. 60 pers/hour a. direction |
| Standard scheduled buses, e.g. with 70 seats and standing room only | 20 minutes | approx. 140 pers/hour a. direction |
| Standard articulated buses, e.g. with 105 seats and standing room | 20 minutes | approx. 210 pers/hour a. direction |
| Trams/light rail vehicles, e.g. in double traction with 175 seats and standing room each | 10 minutes | approx. 1,200 pers/hour a. direction |
| Underground trains, e.g. long trains with 920 seats and standing room only. | 5 minutes | approx. 7,200 pers/hour a. direction |
| Local trains, e.g. long trains with triple traction with 515 seats and standing room only each. | 20 minutes | approx. 1,000 pers/hour a. direction |

| | | |
|---|---|---|
| Regional trains, e.g. Regioshuttle in double traction, each with 175 seats and standing room only. | 30 minutes | approx. 450 pers/hour a. direction |
| Long-distance trains, e.g. 12-seater with 830 seats | 60 minutes | approx. 830 pers/hour a. direction |

Table 3: Typical capacities in public transport per direction in the normal traffic time with usual trip sequence times and 65 % utilisation of the capacity (approximate and exemplary, exact values are to be requested from the respective transport companies) [3].

Module 5 deals with the management of bicycle traffic and the provision of bicycle parking facilities. For example, experience shows that one person, as well as their acceptance and issue of bicycles can guard about 100 bicycle parking spaces.

Module 6 is a core module with a lot of information on planning the flow rates on footpath stages to and from the audience areas as well as on the management of movements and accumulations on the audience areas. In addition to comfort aspects, the goal is in particular the avoidance of hazards resulting from the staging of the event, among other things by optimising the coordination between demand and the space or route available. Local congestion, crowds or high crowd densities, even actual crowding, will be unavoidable at many events, at least temporarily and/or locally. They are not dangerous "per se", but must be recognised, observed and evaluated, and measures must be planned and prepared in order to be able to intervene depending on the situation and with only a short reaction time. The overriding and safety-relevant goals according to which

- all arriving people can be in the audience areas at a time when the experience they expect begins,
- no dangerous situations arise during any of the event phases,
- to react adequately in the event of malfunctions and hazardous incidents,

require careful planning. Module 6 contains requirements, standards and guidelines based on experience that need to be observed for careful planning.

The dimensioning and design of the facilities and offers and the examination of the capacities and the qualities of the traffic flow within the framework of the planning are of great importance. With the help of the listed procedures, it can be checked whether the movements to be expected in regular operation can be made possible, even taking into account expected peaks in attractiveness, and whether the expected number of persons can reach the audience areas as planned and expected and leave them again in a reasonable time. The procedures differentiate between walking spaces that primarily serve the purpose of movement (dynamic use) and other spaces that primarily serve the purpose of standing or sitting (static use). Depending on the space, specific procedures of a suitability test are required. The listed procedures offer the possibility to carry out a rough assessment or dimensioning in the manual calculation procedure. If there is a fundamental uncertainty regarding the feasibility or usability of spaces or of a site, e.g. in the case of complex site structures, dynamic processes or very limited capacities, it may be useful to use microscopic people flow simulations as an alternative to the manual calculation method. If the use of hand calculations or simulation models shows that crowding or congestion is to be expected, this must be assessed. Factors here are, for example, the duration or also the expected crowd density within the crowd. The possibility of implementing measures also plays a role

in the assessment, as do the respective purpose of the space under consideration, the orientation possibilities, the composition and expectations of the people as well as the possibilities of conveying information.

In general, when sizing spaces and paths with dynamic use, it is important to consider that the transition from a moving crowd flow to a congestion depends on individual factors of the people in a cluster and can be recorded far below the possible specific flow at capacity. If congestion is present, the achievable specific flow is low. The congestion can then last for a long time and recovers only slowly and gradually and only if the following number of persons is lower than the achievable specific flow in the congested state. Such congestion can have a significant impact on the comfort of arrival and departure, and especially on the safety of the journey through increased motivation to reach the destination on the "last mile" ("fear of missing out"). These interrelationships justify the principle underlying the EVC of dimensioning such spaces and routes not close to capacity, but at the limit of a probably still stable traffic flow.

The design procedures listed in the EVC are based on correlations between passenger traffic volumes or specific flows, average speeds and crowd densities, which have been derived from current and extensive experiments and can be proven. In the design process, cross sections and in particular bottlenecks in paths or on dynamically used spaces, such as sidewalks, ramps, entrances and exits, corridors, stairs, bridges, fords and zebra crossings, are assessed using a three-level scale (GREEN, YELLOW, RED) (Figure 4). The assessment is based on the highest loaded 2-minute interval. An optimum condition with maximum possible passenger traffic volume with one-way traffic on the level is thus reached at about 1.3 pers/(m*s) to 1.6 pers/(m*s). This capacity limit is reached at a crowd density of about 1.75 pers/$m^2$ and at a walking speed of about 0.70 m/s to 0.90 m/s, at which point crowding already prevails and individual speed selection is no longer possible. The higher the crowd density rises from this state, the lower the speed and the achievable crowd density or rate of passage.

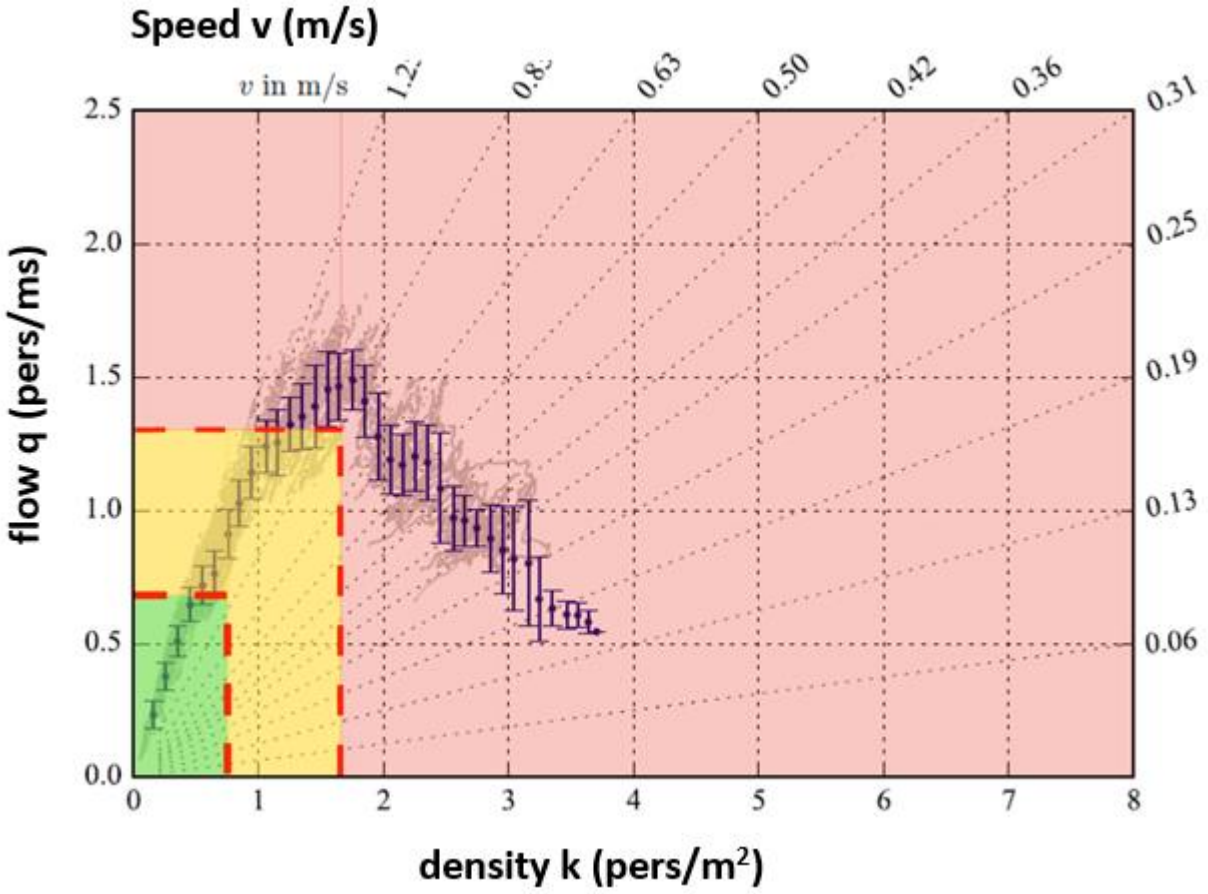


Figure 4: Illustration of the levels of service QSV GREEN, YELLOW, RED for one-way traffic [3].

A free choice of speed or a movement without crowding is possible with people flow densities below about 0.8 pers/m$^2$ based on one-way traffic. In situations with people flow rates between about 0.8 pers/m$^2$ and 1.6 pers/m$^2$ , the risk of transition from a stable state with predominantly walking people to an unstable state with crowding and backlogged people flow rates is high. From a flow rate of about 1.6 pers/m$^2$ onwards, an unstable state with crowding and backlogged flow rates is almost certain. At 0.8 pers/m$^2$ the achievable passenger flow rate is approximately 0.7 pers/(m*s) or 40 to 45 pers/(m*min).

Passenger traffic volumes in the order of magnitude of the capacity values at about 75 to 95 pers/(m*min) can be observed over short periods of one or several seconds, ideally possibly over periods of a few minutes with disciplined behaviour. In crowd flows, disturbances caused by individual behaviour deviating from the optimal behaviour, e.g. by reduced speeds of various persons, are common, so that such high crowd flows can only be observed for short periods of time and only with ideal behaviour.

An unstable condition in a moving crowd flow with crowding and backlogged crowds, which can occur at crowd densities between about 1.60 and 5.50 pers/m$^2$, may pose no or high risks. In this case, congestion leads to high crowd densities. At high crowd densities, it is not possible to make large strides and speeds therefore inevitably decrease. If the speeds drop, the achievable passenger volume drops significantly. If consistently high flow rates then follow, it becomes increasingly congested. In such a congestion, the danger situation is determined not only by the crowd density but also by the mood and motivation of the people in the respective cluster.

In this respect, the results of the dimensioning procedure according to the EVC are to be interpreted and assessed in consideration of the specific framework conditions. For example, expected waiting and congestion situations long before the start of an event can be assessed as acceptable if they are reduced in the course of the arrival time and all arriving persons can reach the audience areas in time before the start of the event. If, on the other hand, it is to be expected that some of the people arriving could miss part of the event due to excessively long lost times, this can lead to high risks. Situations where congestion is possible, likely, almost certain to occur or is likely to occur on the day of the event require closer consideration, monitoring and, in many cases, the use of avoid hazards measures. The EVC contain a great deal of guidance on avoid hazards, interpretation and closer examination of findings during planning and observations during the implementation of an event.

Module 6 also contains information on the dimensioning and management of special situations at ingress control systems and their waiting areas, in audience areas and at emergency exits. Measures for guiding people are addressed. Examples include the controlled feeding of arriving persons to the ingresses and the installation of pressure-reducing barriers. In this way, well-ordered feeding systems (for examples, see Figures 5 and 6) ensure that high crowd densities, unpleasant waiting situations and unregulated accumulations are avoided and that individual approach and influence by the security and public order service is made possible.


Figure 5: Example structure of a queuing system with infrastructural and organisational portioning by numbering (Source: Bernd Belka, Special Security Services Germany) [3].

Figure 6: Example of a queuing system with numbering of people who arrived early before opening and segmentation using flutter tape (source: Lannert/Special Security Services) [3].

Module 7 deals with the monitoring, assessment and management of crowds during an event. Crowding conditions will often have to be assessed subjectively - based on the framework conditions but also on the individual experience of the person assessing. As part of the preparation, it is advisable to carry out exercises, e.g. on assessing densities from different perspectives. Comparative material such as pictures of previous or other events at the venue or an actual simulation and visualisation of different crowd densities in the specific space from the specific perspective can be helpful here. Situation reports from personal walk-throughs, in addition to recording the respective mood situation, can help to identify dangers at an early stage and to react adequately. The EVC contain assessment aids and numerous recommendations on measures that can eliminate or reduce hazards.

Module 8 contains information on the management of incidents and hazardous events. Nevertheless, incident and emergency planning for events is a discipline in its own right, so that the EVC deals with various focal points, in particular the determination of relevant evacuation scenarios and the organisation of an evacuation.

Checklists for basic research, to-do lists and numerous practical examples round off the recommendations on traffic and crowd management for events.

## 4. Conclusion and outlook

At the time of the planning and implementation of the Love Parade in 2010, there was a widespread lack of technical rules that comprehensively dealt with the planning and management of crowd flows and that were introduced as bindingly as possible. In Germany, major gaps were only closed with the EVC recommendations on traffic and crowd management for events published by the FGSV Road and Transportation Research

Association in 2022. In many countries around the world, there are still no regulations or codes of practice that adequately address crowd management in connection with traffic management for events.

The planning and implementation processes of events have certainly changed since the Love Parade 2010. The technical progress of planning tools alone, for example through the use of simulations in the planning process, as well as the means of communication used, for example through the use of digital instead of analogue radio, has improved the safety of events in the last 12 years. The use of simulations is particularly useful for testing and optimising dynamic event management concepts with uni-, bi- or multi-directional crowd flows and/or with potentially highly utilised or overloaded infrastructure elements.

Regardless of this, there is still a need for further research findings, comprehensive handouts up to clear requirements for the planning, licensing and handling of entrances, exits, access routes, junctions and plaza areas as well as for differently controlled access systems for events with specific spectator composition and motivation. In addition, it is obvious to make better use of the technical possibilities in the future. For example, simulations of crowd flows that have been created in advance could be updated in real time by means of observation findings in order to quickly and effectively test the effect of alternative measures on site.

## Literature

[1] Gerlach, J.: Professional processing of the causes of the tragic events at the Love Parade Duisburg 2010 (orig. germ.: Fachliche Aufbereitung von Ursachen der tragischen Ereignisse bei der Love Parade Duisburg 2010), May 2021, [https://doi.org/10.5281/zenodo.6073264].

[2] Wessely, D.; Boehmert, A.: Love Parade - The Trial, Film in the Category Documentary, https://german-documentaries.de/en_EN/films/love-parade-the-trial.19122, available in Germany at https://www.ardmediathek.de/video/dokus-im-ersten/loveparade-die-verhandlung/das-erste/Y3JpZDovL3dkci5kZS9CZWl0cmFnLWQwYmM4MjYxLTM1MjgtNGRhMS1iYzRkLTM0N2RhNDZjNzEzZQ

[3] FGSV Road and Transportation Research Association: Recommendations on traffic and crowd management for events (EVC), edition 2022, Cologne, 2022.

[4] Sieben, A; Seyfried, A: Inside a life-threatening crowd. Analysis of the Love Parade disaster from the perspective of eyewitnesses, manuscript submitted to Safety Science 2023