HERMES – Evacuation Assistant for Arenas

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In modern societies, urbanization and large scale entertainment are obvious trends and consequently, large and complex multi-functional arenas are part of most large cities. The guidance of pedestrian flows in such buildings is a challenge. The Hermes research project, funded by the German Federal Ministry of Education and Research within the Security Research Program, aims to protect and save lives by developing an “evacuation assistant” that could allow stadiums and their venues hosting large events to be cleared quickly and more safely than currently possible. The Hermes system is designed to use information about a current situation to predict what will be the future positions of the occupants. It involves feeding data into a computer program about the availability of rescue routes, fire protection systems, and the distribution of people as determined using video cameras linked to image-processing software. This allows for flexible reactions to the actual situation for which usually no special emergency plans exist.

Design of Evacuation Systems

The dimensions of escape routes are specified in building design codes. Since the reference case is the ESPRit arena in Düsseldorf, Germany (Fig. 1 and [6]), we make reference to the German regulations (“Versammlungsstättenverordnung”, resp. SBauVO, part 1). For a non-roofed sports stadium, a width of 1.20 m per 600 persons (minimum: 1.20 m, increasing in steps of 0.60 m) is required. For roofed sports stadiums the requirements are: 1.20 m per 200 persons, and an additional 0.60 m for every 100 additional persons). In addition to that, different maximum distances are specified such as to a “safe area” (which might be a fire protected staircase). When deviating from those specifications, fire safety engineering methods are used to assure an equivalent level of safety [19]. For sports stadiums, especially the second aspect regarding the maximum walking distance to a safe area is often a challenge. Fire safety engineering methods can be used to assess the escape routes in a holistic manner, though. In this case, required safe egress times obtained from, e.g. evacuation simulations, are compared to available safe egress times obtained on the basis of an assessment of the ventilation and smoke extraction.

The general design process for pedestrian traffic (Fig. 3) also applies to route elements of an evacuation system. As mentioned above, the design criteria according to the prescriptive codes are the length and width of escape route elements. Therefore, prescriptive codes are static approaches not taking into account the crowd dynamics aspects of an emergency evacuation. Hermes on the other hand, is not only a design tool but also covers the operation of the stadium, e.g. the crowd management. To this end, video analysis techniques like detection and tracing are used to adjust the simulation and provide information about the current positions of all persons in the arena (Fig. 2). Based on the forecast of the simulation,

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the security staff can prepare for events to come and can test different strategies to handle a potentially hazardous or very uncomfortable situation. In order to assess the different strategies and their consequences, a level of hazard concept based on the level of service and the crowd density and movement characteristics is used.

The service standards for an evacuation differ from the level of service used for pedestrian walkways, which is based on the notion of comfort [3]. The following table shows the level of service for waiting areas which allows higher densities than for walking areas. It also shows the classification in red, yellow, and green.

Fruin LoS		ft/m 0,3048	
Waiting Area	sq ft / P	sqm/P	P/sqm
A	13	1,2	0,83
B	10	0,93	1,1
C	7	0,65	1,5
D	3	0,28	3,6
E	2,5	0,23	4,4
F	2	0,19	5,3

Table 1: The level of service concept for waiting areas [3]and the red/yellow/green classification.

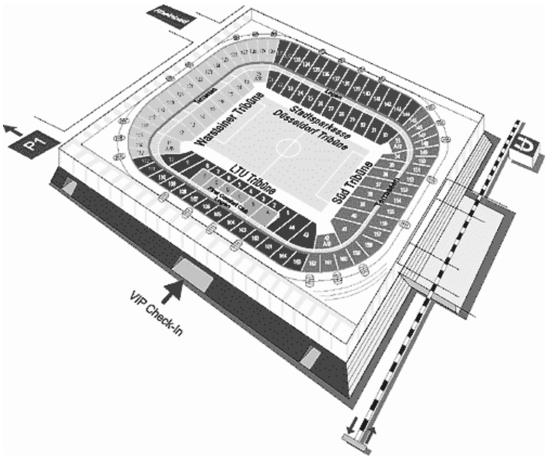

Fig. 1. Layout of the ESPRIT arena.

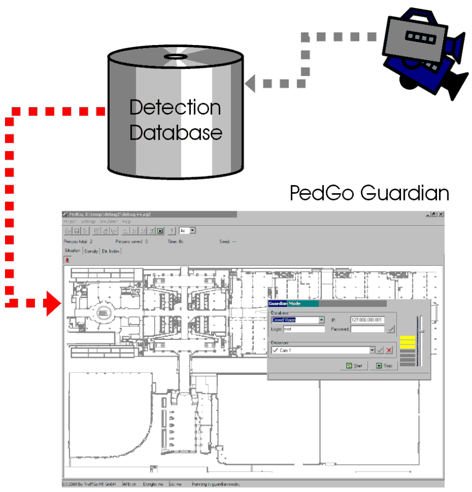

Fig. 2. Detection and tuning.

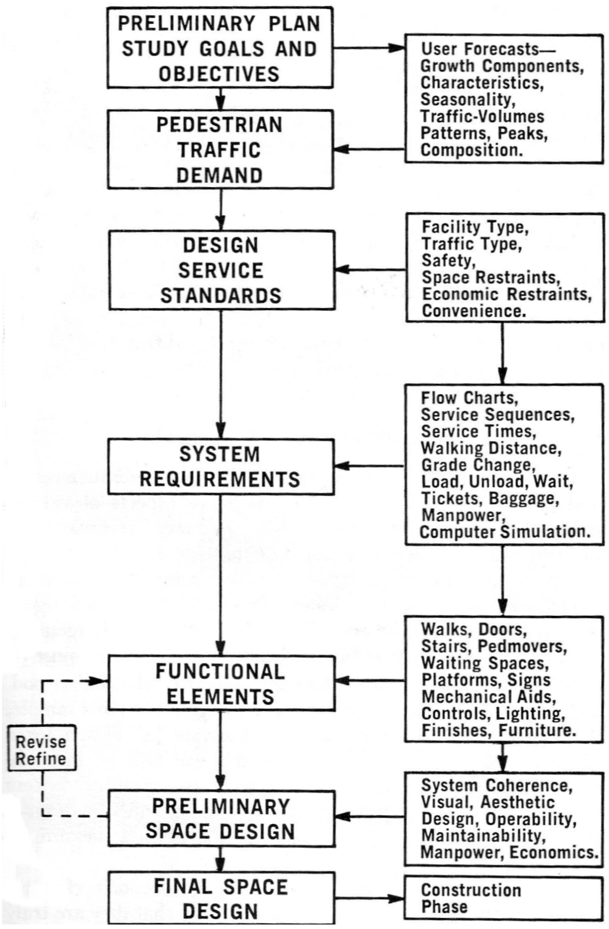

Fig. 3. Design process for pedestrian facilities [3].

The levels A to F are grouped into three broader categories. “Green”, “yellow”, and “red” are the levels used in the evacuation context. For the Hermes project, this more basic scheme is adopted to make it applicable for a command and control center.

Evacuation Simulation

Evacuation simulation is a core part of Hermes. Microscopic simulations predict the motion of more than 50,0000 persons, taking into account individual properties. The information of the detection system about the position of all persons in the arena is processed by the simulation kernel. Similar to a weather forecast, the kernel then computes a prognosis for the situation 15 minutes in the future. An example for the initial situation for a football match with all persons placed initially on the stands is shown in Fig. 4. The red dots indicate persons sitting on their seats. The cumulative local density is one major criterion for identifying congestion. In Fig. 5 the areas where this cumulative local density exceeds 3.5 persons per square meter for more than 10% of the overall egress time is marked red.

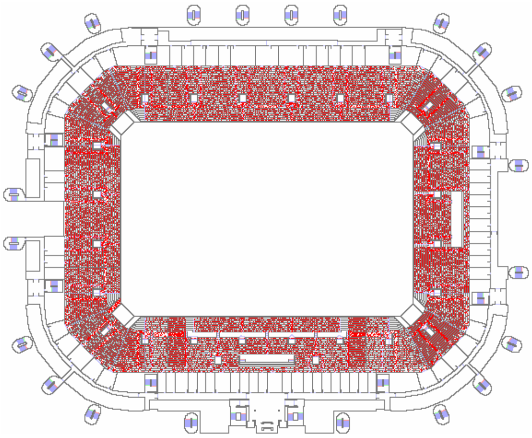

Fig. 4. Floor plan of the ESPRIT arena used in the simulation with PedGo. Red dots show the initial locations of the (non-moving) spectators.

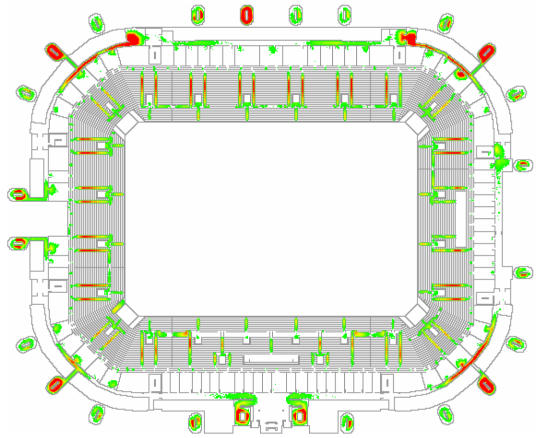

Fig. 5. Simulation result: The cumulative density exceeding 3.5 P/sqm for t □ 0.1 $T_{evacuation}$ (i.e. significant congestion [4] [15]) is shown in red.

Evacuation Assistant

The evacuation assistant will be used by the staff in the command and control center (called “skybox” in the arena) to assess the situation and plan the operation of the security staff and forces.

Class	Risk	Threat	Intervention	Action
5	Severe	Cancel	Secured	Stop Access
4	High	Maximum	Controlled by authorities	Comprehensive Control
3	Raised	Raised	Restrictive	Pat down
2	Watch	Medium	Protective	Restricted Access
1	Low	Minimum	Routine	No Action

Table 2: Risk classification for sports events [13].

The density criterion shown in the table above is only one for assessing critical situations. The green/yellow/red scheme will assist the security personnel to focus their attention. As long as a situation is “green”, no specific attention is necessary. Yellow requires special attention and preparation for crowd management measures and other interventions. Finally, red situations are not acceptable and require specific and immediate action like crowd control. Of course, the challenge is the definition of the demarcation criteria between the different regimes and the calibration of the intervention and action catalogue.

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