Computer Models For Fire and Smoke

Model Name:	ASERI
Version:	ASERI 4.6
Classification:	Evacuation Model
Very Short Description:	Microscopic (individual-based) modeling of egress movement in complex geometries, including behavioral response to smoke and fire spread
Modeler(s), Organization(s):	Dr. Volker Schneider, I.S.T. Integrierte Sicherheits-Technik GmbH, Frankfurt / M., Germany
User's Guide:	ASERI – Users' Guide (hardcopy and complete online documentation – available in German and English)
Technical References:	ASERI – Technical Reference (hardcopy and complete online documentation – available in German and English)
Validation References:	T. Paulsen, H. Soma, V. Schneider, J. Wiklund, G. Løvås: Evaluation of Simulation Models of Evacuation from Complex Spaces (ESECX), SINTEF Report STF75 A95020, Trondheim, Juni 1995 V. Schneider, R. Könnecke: Simulation der Personenevakuierung unter Berücksichtigung individueller Einflußfaktoren und der Ausbreitung von Rauch, vfdb-Zeitschrift 3 (1996) 98 H. Weckman et al.: Evacuation of a Theatre : Exercise vs Calculation, Fire and Materials 23 (1999) 357-361 V. Schneider: Application of the individual-based evacuation model ASERI in designing safety concepts, 2nd International Symposium on Human Behaviour in Fire, Boston, March 2001 V. Schneider: Simulating the Evacuation of Large Assembly Occupancies, Tagungsband 2nd International

Conference on Pedestrian and Evacuation Dynamics (PED), 20.–22. August 2003, Greenwich (London)

V. Schneider: Modelling of human response and behaviour in complex surroundings, 3rd International Symposium on Human Behaviour in Fire, Belfast, September 2004

V. Schneider: Evakuierung und Räumung von Sportstätten und -arenen, vfdb-Zeitschrift 1/2006 (Vortrag anlässlich der VdS-Fachtagung Evakuierung und Räumung von Veranstaltungen, 20. Oktober 2005, Köln)

V. Schneider, R. Könnecke: Egress Route Choice Modelling - Concepts and Applications, 4th International Conference on Pedestrian and Evacuation Dynamics (PED), 26.–29. February 2008, Wuppertal (Germany)

Availability: I.S.T. Integrierte Sicherheits-Technik GmbH, Feuerbachstr. 19, 60325 Frankfurt / M., Germany, Phone (069) 72 11 68, Fax (069) 72 11 94, Email v.schneider@ist-net.de

Price: 13 570.- Euro (not including VAT, including hotline service and training)

Necessary Hardware: PC (at least Pentium III), Windows 2000 / NT / XP, Vista

Computer Language: C++

Size: Approximately 10MB of disk space, at least 256MB of RAM required, disk space for data output depending on scenario and type of output (e.g. detailed animations)

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Detailed Description:

Basic concept

Each occupant is treated as an individual person, moving inside the building or any other geometrical scenario that may be amenable to egress movement (e.g. mass transport vehicles). The individual egress movement is governed by certain behavioural aspects that are triggered by external stimuli and limitations due to the movement of other occupants. Individual decisions and corresponding behaviour may contribute to a delay in starting the evacuation or interrupts, especially in the initial phase of the evacuation process. Furthermore, the choice of the egress path is strongly influenced by individual aspects like knowledge of the building layout or smoke tolerance. Basic features of behavioural response can be modelled in a statistical way.

The probabilistic method allows for a more profound evaluation of the evacuation process by performing Monte-Carlo simulations. A number of replicate runs with identical input data are performed and statistically analysed, yielding not only mean values of egress times but also standard deviations and confidence limits. Furthermore, visualisation of the movement of the evacuees and corresponding dynamic graphical information (including the generation of AVI video sequences) on the population and crowd density in sensitive areas contributes to better understanding of the mechanisms individuals interact with each other and with the physical environment, including fire spread and smoke movement.

Building Layout

In ASERI, the geometrical scenario (building) is defined in a hierarchical way. A building is composed by a number of levels or stories, connected by stairways or ramps. Each level is subdivided into a number of rooms and corridors. Rooms, corridors, stairs and safe areas are the basic geometrical units. These units are defined by the respective ground-plan (generally represented by a polygon) and by size and position of doors and passages. Inside the units obstacles can be defined with arbitrary size and position. Safe areas - the possible destinations of the occupants - usually are regions outside the building associated with exits, but can also be located inside, thus representing regions that (temporarily) give shelter. The number of levels, units, passages and obstacles is only limited by available computer memory. It is therefore possible to model very large and geometrically complex buildings. It is possible to transfer geometrical data directly from CAD-files into ASERI.

Smoke spread and dispersion of combustion products

Time-dependent temperatures and concentrations of smoke, carbon monoxide, carbon dioxide, oxygen and hydrogen cyanide can be related to each unit. Smoke concentration is expressed in terms of visibility.

Individual space requirement

Body size is represented by shoulder and chest width, according to the well-known concept of body ellipse. Furthermore, a minimum inter-person distance and the maintenance of a boundary layer clearance from walls and stationary obstacles is considered. Shoulder and chest width can be assigned individually, either by explicit input or by specifying of a distribution function appropriate for the respective population. By introducing effective size parameters, this concept allows for the definition of persons with increased space requirement, including persons with limited mobility, occupants with luggage or adults accompanied by smaller children.

Individual movement

The occupants’ movement is defined by the individual walking speed and the orientation of the corresponding velocity vector. The orientation is derived from the person's local position and the respective individual goal (e.g. nearest exit or prescribed exit). Furthermore, obstacles and the presence of other occupants influence the movement. Route choice is influenced by external impact and the behaviour of the other evacuees. It is thus possible for an individual to alter the original egress route choice in order to avoid smoke or congestion caused by unbalanced exit use. Hence, individual movement is modelled in a continuous way and no grid is required.

Time is advanced by discrete time steps of 0.5 seconds. For this short interval of time, the corresponding trajectory of a moving person can be represented by a straight line. The movement algorithm of ASERI ensures that no conflict with walls, obstacles or the movement of other occupants occurs.

Impact from fire hazards

The incapacitating effects of exposure to asphyxiates and heat are calculated using the effective fractional dose model of Purser. Based on the movement of the evacuees and the individual dose, exposure is calculated with respect to CO, HCN, CO_2 and O_2 depletion. Synergetic effects, specially hyperventilation caused by the presence of CO_2, are considered in Purser's model. In addition, critical concentration thresholds of toxic fire effluents and oxygen are included in ASERI. Thermal stress caused by radiated or convected heat can also be expressed in terms of an effective dose, considering that short exposure to a high temperature is more incapacitating than a longer exposure to a lower temperature.

The obscuring effects of smoke are described by assigning a time-dependent visibility to each geometrical unit. Beside the toxic effects of smoke components, the slowing down of walking speed due to reduced visibility and certain aspects of behavioural response to smoke are considered in ASERI.