Title: **Evacuation Mode for Total Building Evacuation**

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Mr. Bärlund chaired the CTBUH-initiated work of a 16-member task force that published a study in August 2004 discussing possibilities for evacuation by elevators. He has also co-written two other papers on the subject of evacuation using elevators.

Prior to KONE, he worked with wireless product management in the Finnish telecom sector, sales of investment goods for the ready-mixed concrete industry in northern Europe and Germany, market-entry consulting in Germany, as well as architectural planning in Germany and Finland.

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Evacuation Mode for Total Building Evacuation

This presentation is based on a paper by Kim Bärlund, Ari Kattainen, Marjukka Mäkelä, and Dr. Marja-Liisa Siikonen, all of the KONE Corporation.

This presentation will discuss functional requirements of elevator group controllers of an emergency evacuation elevator system. The focus is on the necessary logic of a total evacuation mode of the elevator system. High-level requirements for both conventional group control and destination group control elevator call allocation systems are described.

Functional requirements concern efficient and optimized evacuation by using assigned evacuation elevators. Better emergency preparation, faster evacuation, and optimized elevator use are some of the immediate benefits of preconfigured evacuation models for an emergency evacuation elevator system.

Main system components are elevator group controller functionalities and a user interface for the emergency management organization. Interfaces between the emergency evacuation elevator system and the building fire systems and various building sensors are also required.

Activation of the evacuation mode prioritizes elevator calls from both elevator vestibules and elevator calls according to the evacuation model stored in the elevator group controller. This means the emergency evacuation elevator system maximizes the number of passengers within a limited period of time who are brought to the egress floors. If evacuation time is critical, then an automatic evacuation mode of the group controller is necessary. In order to maximize traffic handling capacities, an automatic call dispatching is needed.

EVACUATION MODE FOR TOTAL BUILDING EVACUATION

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ABSTRACT

This paper discusses functional requirements of elevator group controllers of an emergency evacuation elevator system. The focus is on the necessary logic of a total evacuation mode of the elevator system. High-level requirements for both conventional group control and destination group control elevator call allocation systems are described. Proofing of the emergency evacuation elevator system against fire, explosion or other threat scenarios is not the topic of this presentation.

Functional requirements concern efficient and optimized evacuation of a building or a building zone by using assigned evacuation elevators. Better emergency preparation, faster evacuation of a building and optimized use of elevators are some of the immediate benefits of pre-configured evacuation models for an emergency evacuation elevator system.

Main system components are elevator group controller functionalities and a user interface for the emergency management organization. Interfaces between the emergency evacuation elevator system and the building fire systems and various building sensors are also required. Evacuation elevators should also be provided with emergency power.

Activation of the evacuation mode prioritizes elevator calls from both elevator vestibules and elevator calls according to the evacuation model stored in the elevator group controller. This means that the emergency evacuation elevator system maximizes the number of passengers that within a limited period of time are brought to the egress floors.

If evacuation time is critical then an automatic evacuation mode of the group controller is necessary. In order to maximize traffic handling capacities, an automatic call dispatching is needed.

EVACUATION MODE LOGIC

Introduction

This presentation focuses on elevator controller functionalities, and will not discuss necessary fire / explosion etc. proofing of the elevator systems. The goal is to give the reader an understanding of measures necessary to improve traffic handling capacities when passenger flow is mainly towards the emergency exit floors of a building.

The importance of emergency evacuation drills cannot be overstressed. Even the most sophisticated equipment is useless if the regular tenants and the internal and external emergency management organization are not up to date concerning how to use the apparatus and what its role in the emergency situation is.

A building's emergency evacuation elevator systems comprise only one part of a buildings egress routes. Mixed use of elevators and stairs is the most efficient way to empty a building. How the use of stairs and elevators is organized, is dependent on the building architecture and needs to be defined case by case through building-specific evacuation planning[i].

Elevator functionality can be maximized to speed up the transportation process but they cannot in any way replace a building's emergency management systems and routines. In other words, the time it takes for the security personnel in a building to detect an emergency and to make an evacuation decision is dependent on other parameters and procedures than those resident in the building's elevator system. The Operator of the security center's elevator monitoring system must manually start building evacuation and approve of elevator mode changes.

The goal of a functioning evacuation mode is to optimize the elevator handling capacity so that passenger transportation towards exit floor(s) consume as little time as possible. In order to achieve this, some alterations to the elevator system's normal mode functionalities are necessary. There is also a clear difference between conventional elevator control systems and destination call systems.

Core requirements of an emergency evacuation enabled elevator system concern the elevator controller functionality and the security center user interface of the elevator monitoring system. The different elevator drive modes have different priorities depending on the situation at hand. A rule of thumb is that emergency drive modes override standard drive modes.

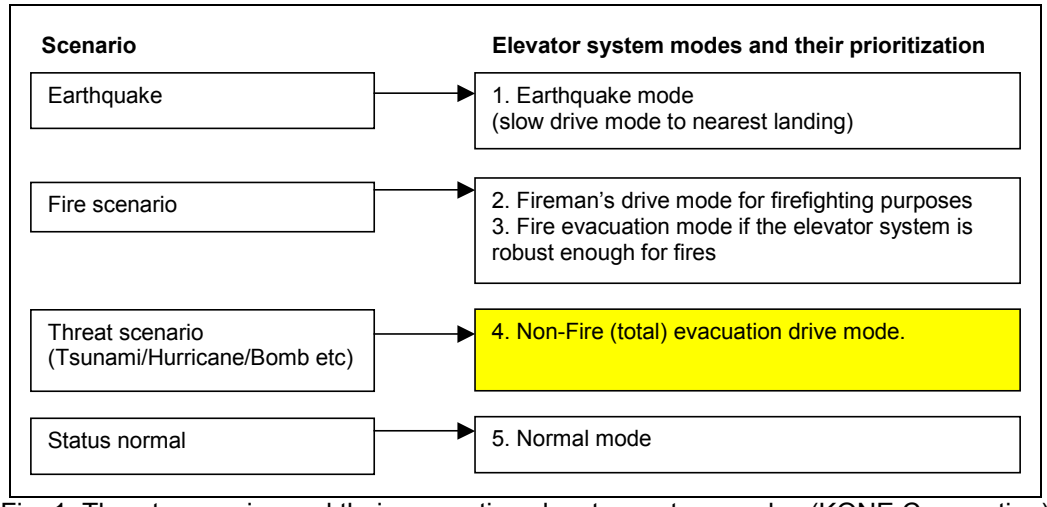

Fig. 1. Threat scenarios and their respective elevator system modes (KONE Corporation)

The order of elevator system mode prioritization is proposed in Fig.1. The situation at hand dictates the mode to be used. This Figure shows how non-fire total evacuation mode relates to other possible evacuation modes.

Non-fire evacuation is more straightforward than a fire evacuation mode and could in principle be carried out with standard elevator systems. Non-fire (total) evacuation becomes necessary mostly in situations where the building and its systems are under threat, but not yet damaged. These non-fire events include electric blackout and therefore auxiliary power systems are required in addition to "standard" elevator equipment.

The fire evacuation mode differs from non-fire evacuation. In fire evacuation the buildings fire system integration and inputs from smoke/temperature/etc. sensors are required in order to ensure safety of fire evacuation. There are also additional system robustness requirements on building architecture and structure to ensure protection for the elevator system.

Requirements on protected elevators, mainly used for staged evacuations, are discussed in detail in the publication on emergency evacuation elevator systems published in 2004 by the Council on Tall Buildings and Urban Habitat. The same publication also describes detailed requirements for successful fractional evacuation, i.e. evacuation of occupants with temporary or permanent disabilities.

If the elevator system is protected against extraordinary events like explosions and toxic substances then the fire evacuation mode, as shown in Fig 1. may be extended to include extraordinary scenarios as well.

Elevator controller requirements

To maximize transportation capacity elevator hall calls are registered only on evacuation floors. Both "Up" and "Down" hall calls are collected in the direction of emergency exit floor(s) only, disregarding the direction of placed landing calls. The elevator cars are filled to maximum capacity at each stop to further increase traffic handling capacity.

Elevator car calls are interpreted by the system as a car call towards the emergency exit floor(s) regardless of which floor button is pressed. Emergency egress floors are defined in the evacuation plan of the elevator controller.

The evacuation plan is stored in the Group Controller. In total evacuation mode the evacuation plan means that all floors are emptied and passengers taken to the emergency egress floors. The default egress exit is usually the main entrance. Emergency egress exit floors can be defined online from the elevator monitoring system if a deviation from the default floor is needed.

When the evacuation floors and emergency evacuation elevator groups are defined, the emergency evacuation elevator group control automatically takes care of evacuation according to its efficient up-peak and down-peak algorithms.

Requirements for destination call allocation elevators

Destination elevator calls are personalized calls. In an evacuation mode the elevator system should consider all occupants of a floor – not personalized calls. Destination floor calls are disregarded and the emergency exit floor is regarded as the destination floor. Elevator calls are transformed into ordinary floor calls to the floor where the call is placed. The elevator collects the transformed calls towards the emergency egress exit floor. The destination operation panel shows a text saying “Take elevator X to the emergency exit floor Y” until the elevator X arrives to the evacuation floor.

INTERFACE REQUIREMENTS

Passenger and security center personnel interface requirements

Elevator call devices. To ensure usability of the system, the same user interfaces for passengers are used in both normal and evacuation modes. To minimize stress and confusion, total evacuation scenarios do not allow for special user interfaces placed behind fireman’s control type of locked panels or keyswitches. This is a practical issue as well as an issue related to possible time-criticalities of evacuation. The goal must be that passengers use the elevator in exactly the same way as during normal mode, but that the elevator controller registers placed calls differently.

Elevator monitoring system. Configuration and updating of the evacuation plan shall be possible through the elevator monitoring system’s user interface. Emergency egress exit floors must be configurable “on-line”. Possibly there is a need for several default evacuation plans that are easy to activate during given emergencies (i.e. emergency exit floors vary). The evacuation mode is activated and deactivated from the monitoring system user interface by the security center personnel.

System interface requirements

To integrate the emergency evacuation elevator with building management systems (BMS), there are additional requirements for building-elevator interfaces. Interface specifications require cooperation between specialist planners, so that safe waiting lobbies, building automation input, power supply redundancy and integration into building-in-use-processes are provided.

Building system interfaces

Fire system input. If the emergency evacuation elevator system is intended for evacuation in fire scenarios, possible fireman’s drive mode options must be disabled in evacuation modes. Most fire evacuations take place very early on during a fire scenario, which means that fireman’s use of lifts takes place after evacuation. The security center operator activates and deactivates the evacuation mode.

Alerts from fire and smoke (in some cases gas) systems trigger predefined evacuation procedures. Upon inputs from such systems the elevator evacuation mode may be triggered automatically or the building security personnel can trigger it manually. Up-to-date systems also give location of hazard and predefined exit floors. This aids the security center operator in further actions.

During evacuation operation, fire and smoke (in some cases gas) warning system inputs monitor whether the smoke/gas and temperature level in the exit floor lobby, hoistway or car are compromising tenability or elevator system functionality. If safety is at risk the detection systems inputs cause the emergency evacuation elevator to drive to the nearest safe landing

Detailed specifications are needed to define what are acceptable conditions in elevator lobbies to allow the elevators to stop at any given floor during fire/explosion/etc. emergency evacuation. Parameters to research

are heat, smoke, and possibly gas/toxic substance levels. These need definitions and decisions case-by-case depending on the building's risk/threat profile.

REQUIREMENTS DERIVED FROM TIME CRITICALITY

Traditionally evacuation of high-rise structures has taken place as staged evacuations. New threat scenarios call for standardized total building evacuation procedures. These threats are most often time critical and it is essential to carry out an orderly evacuation within as short a time as possible. Situations involving actual ongoing building system destruction (fire, explosions etc.) are even more time critical.

Experts participating in the ongoing discussion on evacuation have suggested different evacuation time criteria. In well-planned office buildings, a viable elevator evacuation time is around 30 – 30 minutes. Using both elevators and stairs, an evacuation time below 20 minutes can be expected.

To minimize time spenditure the elevator systems traffic handling capacity needs maximization. Traffic handling capacity is maximized when the elevators round trip time, including loading and unloading of the elevator, is as short as possible. Some considerations are listed below.

First of all the efficient dispatching algorithms of the elevators must be utilized in order to maximize traffic handling capacity. Manual dispatching, as in fireman's drive mode, can never compete with the efficiency of automatic dispatching.

The emergency evacuation elevator always takes as full a load as possible during each stop with a minimum number of stops in one round trip.

In evacuation drive mode, standard comfort is neglected to gain max efficiency. Acceleration and deceleration shall be carried out at maximum power, without compromising machinery.

Every started trip must be completed disregarding failure of non-critical components.

The emergency evacuation elevator system starts to close doors when 80% of possible load (mass) has entered the emergency evacuation elevator. If there is an obstruction in front of the emergency evacuation elevator doors the emergency evacuation elevator shall start closing its doors by activating the door nudging option. This helps to avoid overload situations that impede the departure of the emergency evacuation elevators.

The emergency evacuation elevator evaluates occupied floor space, e.g. how full it is (volume). This prevents the emergency evacuation elevator to stop at other floors even if it is not loaded to its full mass capacity. This is useful for example in cases where there are wheelchair users or bed-patients etc.

CONCLUSIONS

Given careful planning and possible emergency scenario pre-modeling, elevators may be used for total building emergency evacuation. The first application is non-fire evacuation in threat scenarios, where all systems are intact. Building robustness requirements may never permit the omission of staircases as redundant egress routes.

Prerequisites for functioning emergency evacuation elevator systems are that its user interfaces are the same as in normal mode and that elevator-monitoring systems are equipped with highly usable evacuation management tools that are part of the elevator and building management system solution.

Emergency evacuation elevator systems are useless without regular training for building tenants and personnel alongside conscientious system maintenance.

Further research should be carried out on more demanding fire evacuation scenario requirements concerning acceptable conditions in waiting areas, the elevator cars and hoistways. Levels of heat, smoke, toxic substances etc. all need further research and cross-scientific cooperation between vertical transportation, building design and fire experts.

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i) Council on Tall Buildings and Urban Habitat, 2004. Emergency Evacuation – Elevator Systems Guideline. Chicago: CTBUH, ISBN 0-939493-21-7.