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PLANNING AND IMPLEMENTING AN EMERGENCY EVACUATION ELEVATOR SYSTEM

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Abstract:

This paper integrates the planning and implementation process of an emergency evacuation elevator system into the building planning process. The system is activated when partial or complete evacuation of a building is needed. The system specification is defined by building evacuation goals established early in the programming phase of a building project. This leads to requirements concerning the building's spatial organization, its structural- and automation systems, effectively the building concept itself becomes influenced by the requirements of an emergency evacuation elevator system.

Due to of the wide impact of emergency evacuation elevator system requirements, early cooperation between stakeholders (authorities, planning disciplines including elevator system specialists, building staff and tenants) is vital. Issues that stakeholders and planners must consider during the different phases of a building project are described phase by phase. To understand additional requirements on an emergency evacuation elevator system service, the emergency evacuation process is also briefly analysed.

Keywords: Tall buildings, Building planning process, Safety, Emergency evacuation elevator system, Simulation

1. Introduction

Emergency evacuation elevator system requirements mentioned here, are more or less known by the elevator industry, some articles where requirements have been discussed, are mentioned in the reference list. The novelty of this paper lies in the consolidation of known functional requirements for emergency evacuation elevator systems, with the building process. The writers believe that a pragmatic view on the subject can be achieved through this process approach.

This paper generates an understanding on the planning and implementation process of an emergency elevator system by first analysing the stakeholders' roles during the building process phase by phase and then by briefly analysing additional requirements from the generic emergency evacuation process. By analysing requirements through both the building and the evacuation process an understanding of the planning process for the product itself and the additional services it requires is achieved.

This paper focuses on emergency evacuation elevator systems for tall buildings. Scenarios that might require evacuation are for example: Fire, Chemical spills, Bomb threat or explosion, Violent attack or Bio-terrorism. Some other threats might be identified as well, depending on the risk analysis for the location and activities. These are to be identified through the risk analysis during the building project itself. (National Safety Council, 2002, Lawrence G. Perry, 2000).

2. An Analysis of Requirements for the Planning and Implementation Process of an Elevator Evacuation System

2.1 Planning and implementing requirements during the building process

In planning and implementing a successful evacuation elevator concept it is essential to integrate the emergency evacuation elevator system concept to become part of the whole building concept and the security plan. The main goals of the security plan of the building, including the tenants' security plans, also define the main goals for an emergency evacuation elevator system. A successful evacuation system will have to be planned closely in cooperation between the different planners and stakeholders, because it integrates with systems and principles that are defined by different planning entities and chosen by different stakeholders.

The main activities and issues for the stakeholders during each building project phase are briefly listed below. The names for and division into different building process phases vary somewhat from country to country. The construction process nevertheless proceeds with the same kind of iterative logic on different markets. Thus the writers' opinion is that the procedure described here on a general level, can be applied on different markets fairly well. The process phases described here represents the view that has been amalgamated through work experience of the writers and through discussions with Juhani Kiiras, professor at the Institute of Construction Economics and Management at the Helsinki University of Technology in Finland.

Programming	Sketch design	Engineering	Procurement	Construction	Occupation
• Feasibility study • Building location, use, size, targeted tenants • Main goals for security plan, including evacuation goals	• Design concepts • Building shape, form • Draft security plan, including evacuation plans	• Finalised feasibility study • Technical documentation for building permission, procurement and construction	• Fulfilment of specifications cost and time-effectively	• Fulfilment of specifications time and cost-effectively	• Startup of building application • Maintenance

Fig. 1 Building process phases

2.1.1 Emergency evacuation elevator system issues in the programming phase[1].

During the programming phase, size and costs of the project are defined at a rough level. Mostly this is done in a verbal and numeric format but sometimes the starting point is a sketch drawing or visualization of the building. When programming a project, there is a vision of who the future tenants of the building might be, and normally the building location is known. Location, building and tenant type enables a preliminary risk and threat analysis and a definition of the desired security level including evacuation goals. Main requirements for the evacuation plan should be defined at this stage. This includes, for example, the desired evacuation time. Estimating the desired security level of future building tenants helps in defining a workable security concept from the very beginning of a project. Flexibility of the implemented evacuation plans is necessary because tenants might relocate.

The inclusion of emergency elevator systems into the evacuation plans raises a number of issues that must be addressed early in the building project. It, managed this way, it will reduce the number of changes at later stages of the project that normally impact project costs. Perhaps, the best specialists on emergency evacuation elevator systems are elevator companies and elevator consultants. These provide expertise to building developers and planners, related to the preliminary security plan and its evacuation concepts.

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[1] Terms like "feasibility planning", "business case", "preliminary design", " statement of need" or "brief" are also used to describe the activities of this phase. (Gray and Hughes, 2001, Mindt, 1999, Rakennustietosäätiö, 1989)

Issues affecting the evacuation elevator concept:

- Who are the future users of the building? For example: 5-10% are disabled (Developer)
- Where will the building be located? (Developer)
- What are the threats? (Risk consultant)
- What are the different evacuation scenarios that apply in this context? (Risk consultant)
- In which scenarios are authorities allowing evacuation by elevators? (Authorities, Norms)
- Is the evacuation elevator option feasible? (Elevator companies and consultants)
- How does the emergency evacuation elevator system add value to the building? (Developer, Elevator company, Consultants)

2.1.2 Sketch design phase[2]

In the sketch design phase the building purpose and targeted end users become more defined. The room programme from the previous phase is detailed enough for architectural planning. At this stage the main driver of the building concept is often the architect, at least in terms of building shape and form definition. The concept for the building structure is most often derived from the building concept and shape. Sometimes a structural idea may define the architectural concept. From the security planning point of view, the physical characteristics of the building become more defined, which means that the number of occupants are more precisely known and traffic flows can be analysed.

Requirements for the elevator system have to be carefully considered at this stage. The planned evacuation concepts, including the role of the elevators during different phases of the emergency situation, must be analysed in relation to the set evacuation criteria (time, evacuation of disabled etc). For the evacuation use of elevators, this means that safe elevator lobbies and exit floors of the emergency evacuation elevator system should be integrated into the building design concept (Klote, Levin & Groner, 1997).

At this stage building automation concepts are being considered. In evacuation it must be ensured that there is an infrastructure that supports communication to occupants and also communication between building automation systems and the elevator system (Klote, Levin & Groner, 1997).

The traffic flows of the building during an emergency have to be simulated for the specific layouts of the building (sketch designs). Different placement options of evacuation elevators and emergency stairs are evaluated in the simulation. The building traffic simulation helps to optimise the evacuation concept. The Kone Building Traffic Simulator (Kone BTS) is one of the very few on the market, where vertical transportation is configured using actual elevator system algorithms. Stairs and horizontal movement are also included.

Issues affecting the evacuation elevator concept:

- Physical characteristics of the building, i.e. size of floors and population. (Architect, Developer)
- How are safe areas provided for people waiting for elevators? (Architect, Structural engineer)
- What is the emergency stairway and elevator distribution in the building? (Architect, Consultants, Elevator company, Authorities)
- What is the approximate needed capacity of elevators, derived from building floor space and assumed population? (Elevator companies and consultants)
- How do the applicable evacuation scenarios work for this design? (Elevator company)
- Does the evacuation concept meet the set requirements? (Developer, Risk consultant, Elevator company, Architect, Authorities)

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[2] Sketch design, project planning stage, outline design or scheme design are also terms used to describe this phase, where physical aspects of the building concept take form. (Gray and Hughes, 2001, Mindt, 1999, Rakennustietosäätiö, 1989)

2.1.3 Engineering[3] and procurement phases

The design is 'frozen' and the necessary construction documents that enable procurement and actual construction are created. For emergency evacuation elevator systems, precise traffic calculations and evacuation simulations can be carried out in order to determine optimum capacities. In this phase also exit floors, safe waiting areas etc concerning the building concept are 'frozen'.

Building automation system specifications are defined and finalized at this stage. Pressurization concepts for stairwells and shafts, electrification issues and the emergency evacuation elevator systems' interfaces to fire systems are related to the emergency evacuation elevator system (Klote, Levin & Groner, 1997). Interfaces should include the building control centre's building management system application. It is essential that the interfaces of building systems communicating with each other to provide the evacuation concept services, are well defined. This means cooperation between system providers (Fire system, Gas warning system, HVAC, Lighting systems, Building management system etc.).

Issues affecting the evacuation elevator concept:

- Finalised evacuation scenarios where elevators are used and definition of when they no longer are used. (Risk consultant, Elevator company, Authorities)
- Finalised elevator capacity calculations and evacuation simulations for finalised building plans. (Elevator company)
- Finalised concepts for providing safe waiting areas and redundant escape routes. (Architect)
- How is the emergency evacuation elevator system triggered? (Elevator company, Automation engineering)
- How is the alert communicated to occupants? (Electrical engineer, Fire systems designer, Risk consultant)
- Finalised building automation concepts, including central control room application (Automation providers, System integrator)
- Finalised concepts for auxiliary power sources. (Electrical engineer)
- Approval of concepts from authorities. (Authorities)

2.1.4 Construction

The main objective in the context of emergency evacuation elevator systems is to supervise that the emergency evacuation elevator system is realised according to plans made out in previous phases.

Issues in the evacuation elevator implementation:

- Test that the evacuation concept performs as specified.
- The construction project management organisation has a supervisory function. (Architect, Project engineers)

2.1.5 Authority inspections before occupancy start

Authorities give building approval and give permission to start to use the building. During the start-up phase, building staff and possibly tenants are trained in the use of elevators in an emergency according to the specific evacuation plans of the building. The building application starts running (office, residential, hotel etc.).

Issues in the emergency elevator system implementation and operative phase:

- Security service providers are trained how to use elevators in evacuation situations. (Elevator company)

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[3] This phase can also be called "pre-contract stage" or "design and production stage" or similar. (Gray and Hughes, 2001, Mindt, 1999, Rakennustietosäätiö, 1989)

- Building tenants are trained how to use elevators in evacuation situations. (Elevator company)
- Definition of the buildings' emergency management team (Building owner, tenants)

2.1.6 Occupancy and Maintenance

The emergency evacuation elevator system functionality has to be tested at specified intervals. This includes interfaces to other systems. Preventive maintenance is essential to ensure that the system works in a real-life situation.

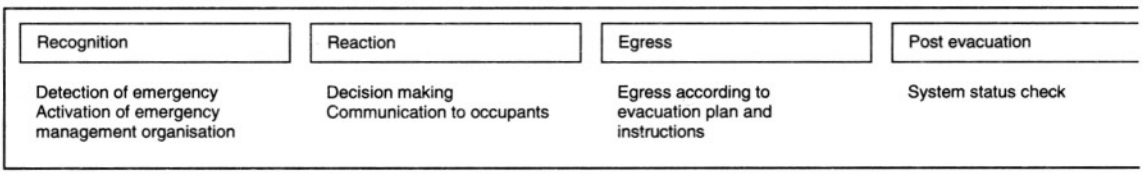
Issues in the emergency evacuation elevator system operative phase:

- Maintenance of elevator system (Elevator supplier)
- Maintenance of security system (Security system suppliers)
- Maintenance of Building management systems (control room application) (Building automation systems integrator)
- Definition of and training of the building's emergency management organisation (Tenant, Building owner, Security service provider, Elevator provider)
- Tenant evacuation drills (Building staff)

2.2 Planning requirements analysed from the evacuation process

This section describes the progress of the evacuation process in order to identify additional requirements on an emergency evacuation elevator system. Evacuation time is broken down into three phases: Recognition, Reaction and Egress (Siikonen and Hakonen, 2002). In the context of emergency evacuation elevator systems it is beneficiary to broaden the view to include post-evacuation as well. Thus we get four stages: Recognition, Reaction, Egress and Post-evacuation. Requirements that stem from these phases are analysed below.

Figure 2. Evacuation process flow



2.2.1 Recognition

Awareness of an emergency can come either from automatic equipment or by manual alert. Automatic systems that are fairly common today include sprinkler systems, smoke and heat sensors. Automatic warning systems are also available for gas or other substances. Manual alerts come to the building security by the building's fire emergency button, telephone, mail, email, fax, person etc. These warnings and alerts activate the buildings' predefined emergency management organisation into action.

For the emergency evacuation elevator system the main issue is how to communicate to the elevator that there is an impending evacuation situation and which floors are to be evacuated. System interfaces have to be defined that communicate the fire system's and other systems' signals to the emergency evacuation elevator system. This signal can trigger an automated evacuation mode that waits for acceptance from building security. For manual triggering of the evacuation mode of an elevator, an input device in the control room is necessary.

Issues concerning the emergency evacuation elevator system in operation:

- How is evacuation communicated to the elevator?

2.2.2 Reaction

In order to be able to decide and react properly during emergencies the importance of preparedness is very high (BOMA International 2000). The basis of a successful evacuation is planning and training with the security management organisation (building staff, security function and at least part of the tenants).

Issues concerning the emergency evacuation elevator system in operation:

- Do authorities and building owners permit automatic evacuation routines for this location?
- Who in the building's emergency management organisation decides whether to evacuate or not?
- How is the evacuation procedure communicated to or generated in the emergency evacuation elevator system?
- How is the evacuation communicated to the occupants?
- Do the occupants know what is expected from them?

2.2.3 Egress

The movement phase is the time it actually takes to move evacuees into safety, once the evacuation alarm has been given. For greater efficiency, people have to know when the elevators can be used and when they cannot be used. Also, additional information to reduce stress at waiting locations will be necessary.

Issues concerning the emergency evacuation elevator system:

- How is the status of the elevator system communicated to occupants?
- How long will evacuees have to wait for the elevator?
- How are the emergency evacuation elevator systems to be used?
- What is done to alleviate stress and panic?

2.2.4 Post-Evacuation

Besides from post-emergency counselling of evacuees, also the emergency evacuation elevator system will need a thorough inspection and possible maintenance work. This inspection will be necessary in order to provide the reliability required.

3. Discussions

The model presented here is a high-level overview of the emergency evacuation elevator system planning process and how it integrates into the entire building planning process. There will inevitably also be variations from one country or market area to the next. The table below summarises the issues to be considered during different phases of a building project. Sometimes the player can have more than one role; it varies from project to project.

Technically the emergency evacuation elevator system can be fairly standardised, considering also the probable direction of future normative work – it is nevertheless important to go through the goal setting and specification procedure in accordance with the iterative logic of a building project in order to integrate the emergency evacuation elevator system into the building concept, including the building's operative phase.

Player/Phase	Programming	Sketch design	Engineering	Procurement	Construction	Occupancy start
Tenant	• Security needs	• Iteration of needs	• Iteration of needs			
Developer	• Use, location, size • Targeted occupants • Building concept budget • Desired security level	• Defines targeted performance of building in evacuation situations	• Management function			
Risk Consultant	• Threat scenarios	• Security concept with evacuation scenarios • Spatial organisation and structural requirements related to evacuation in perceived situations	• Finalised security concept, including evacuation plans • Systems and automation requirements related to perceived threats • Definition of when elevators can and no longer can be used • Guidance concepts	The buying centers vary depending on contracting modes, which will not be discussed in detail in this paper. In the context of emergency evacuation elevator systems, the following is still generally applicable: The objective of the buying functions and construction functions is to make certain that the specifications generated in the planning phases of a building project are purchased efficiently and that they are built according to specifications. This is supervised through both internal revisions, buyers' inspections and authorities' inspections. Corrective actions, and handovers marks the end of the construction phase.		• Training needs Handover to future building owner and or tenants • Start-up training for building staff and occupants • Maintenace and tests of emergency elevator evacuation system for performance and reliability • Approval to start to use the building
Architect	•Consultative function	• Form and shape • Fulfilment of spatial organisation needs, f.ex safe waiting areas, exit floors, redundant exit routes etc.	• Integrating different spatial and systems requirements so that space is organised and provided for • Guidance concepts			
Elevator company/ consultant	• General info on Emergency Evacuation Elevator Systems (EEES):	• Consultation on capacity and performance of EEES. • Building traffic simulation • Building evacuation simulation	• Definition of when elevators can be used and when they no longer can be used • Communication interfaces to building automation and security systems • Communication interfaces to occupants, for emergency use			
Structural engineer		• Structural concept	• Definition of how safe areas and exit routes are constructed			
Electrical Engineer		• Electrification concept	• Redundant power cables and power sources for the EEES.			
HVAC Engineer		• HVAC concept	• Pressurisation concept for EEES shafts • Communication interface to EEES			
Automation Providers		• Automation concept	• Communication interface to EEES • Communication infrastructure			
Security systems provider		• Security system concept	• Communication interface to EEES			
Authorities	• Consultative and normative function	• Consultative and normative function	• Approval of scenarios where an EEES may be used • Definition of when elevators can be used and when they no longer can be used			

Table 1. Stakeholders' tasks related to an emergency evacuation elevator system during the different phases of a building project. EEES= emergency evacuation elevator system.

Conclusions

The main goals for the security plan, hence also for the evacuation plans, have to be readily defined during the programming phase of a building project.

Risk assessment needs to be integrated into the concept development and planning phases at an early stage, to ensure cost effectiveness and functionality of evacuation systems and measures.

The role of elevators in the evacuation plans has to be analysed in the early sketch design phases – this means involvement of elevator specialists.

The feasibility of evacuation plans, that include elevators have to be simulated to guarantee that requirements set for the evacuation concepts are met.

An emergency evacuation elevator system is a complex system that requires contribution from many planning disciplines jointly. This makes cooperation between subsystem providers essential and influences procurement decision-making.

Tenant education and training is necessary for a successful use of emergency evacuation elevator systems in real life situations.

Preventive maintenance is important to ensure a working emergency evacuation elevator system throughout its life cycle.

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