# Evacuation dispatching: strategies to get as many people out as possible as quickly as possible using lifts

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**Abstract.** Modern lift dispatchers are designed to optimise passenger waiting and transit times, with a relatively small proportion of the total building population using the lifts in any 5-minute period. In an evacuation scenario, the passenger demand is significantly higher, and conventional dispatching strategies are no longer optimum. In this paper, the author explores how to increase handling capacity so that lifts can help empty buildings as quickly as possible. Lessons from round-trip time calculations and traditional dispatcher design strategies are considered to help understand how to optimise lift evacuation. Risk-based evacuation prioritising floors according to their likely order of being compromised is explored. New user interfaces are needed to inform and reassure anxious passengers waiting for evacuation.

## 1 INTRODUCTION

This paper provides insights into strategies and technologies for improving lift evacuation efficiency and thus enhancing safety in high-rise buildings.

Modern lift dispatcher systems are optimised for routine passenger flows, typically handling a small proportion of the building's population within a five-minute period. However, passenger demand surges during an evacuation, making conventional strategies ineffective.

This paper investigates methods to increase lift handling capacity for swift building evacuation. By examining round-trip time calculations and traditional dispatcher strategies, the study aims to optimise lift performance in emergencies. Additionally, it explores risk-based evacuation, prioritising floors based on their risk of being compromised.

New user interfaces are also discussed, emphasising the need to inform and reassure passengers during evacuation.

The requirements and design aspects of evacuation lifts have been extensively covered in various sources [1] [2] [3] [4] [5] [6] [7] and will not be the focus of this paper. However, to provide a complete understanding of the regulatory context, it is necessary to reference the International Building Code (IBC) [8] and ANSI A17.1 (ASME A17.1) [9], which are essential for guiding the design and operation of evacuation lifts in the U.S. The IBC addresses safety requirements during emergencies such as fire protection and communication systems, while ANSI/ASME A17.1 offers detailed technical standards for Emergency Power and Firefighter's Emergency Operation.

In contrast, prEN 81-76, a European standard, focuses specifically on the evacuation of persons with disabilities using lifts, emphasising accessibility and operational procedures unique to the European context. While the IBC and ANSI A17.1 provide broader safety guidelines, prEN 81-76 is tailored to ensuring safe evacuation for individuals with mobility impairments. Referencing these standards highlights the differences in regional approaches to evacuation lift design and implementation, contributing to a comprehensive understanding of the topic.

## 2 INCREASING HANDLING CAPACITY

### 2.1 Lessons from round-trip time calculations

Consider the classical uppeak round-trip time calculation [1]

$$RTT = 2Ht_v + (S+1)t_s + 2Pt_p \qquad (1)$$

where:

| | |
|---|---|
| $H$ | Average highest reversal floor (value) |
| $P$ | Average number of passengers (persons) |
| $RTT$ | Average round trip time (s) |
| $S$ | Average number of stops (value) |
| $t_p$ | Average single passenger transfer time (entry or exit) (s) |
| $t_s$ | Time consumed in stopping (s) |
| $t_v$ | Time to travel between two standard pitch adjacent floors at rated speed (s) |

If we can reduce the number of stops ($S$) and the average highest reversal floor ($H$), the round-trip time ($RTT$) will become smaller. This is what happens when you implement a group collective down-peak algorithm [10], as illustrated in Figure 1. The building is divided into sectors, and the dispatcher sends a lift to each sector's top-down call in turn. The lifts are not fixed to a particular sector as the round-trip is longer for a higher sector than for a lower sector. In this specific implementation, if the lift is not full when it reaches the bottom of its sector, it can stop for additional passengers as it passes through lower sectors.

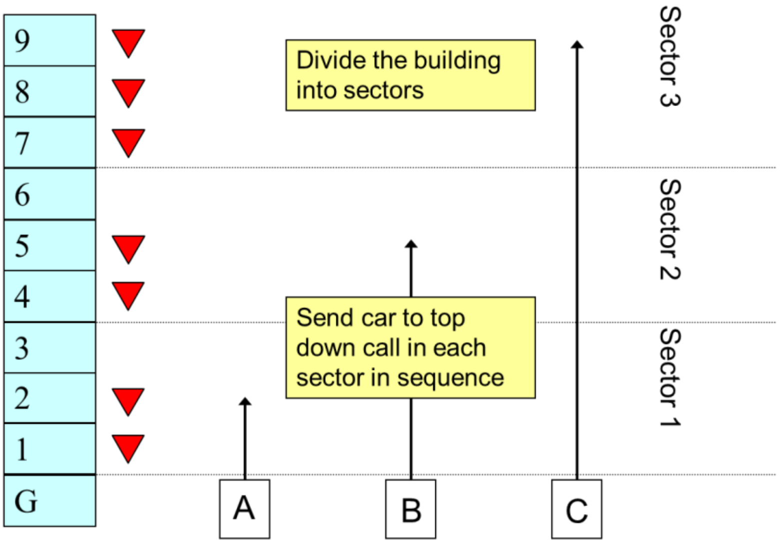

**Figure 1 Down peak algorithm**

### 2.2 Uppeak handling capacity using simulation

To illustrate the impact, consider a simulation applying a group collective uppeak dispatcher algorithm and step profile where, every five minutes, the uppeak passenger demand increases by ten persons per five minutes, see Figure 2.

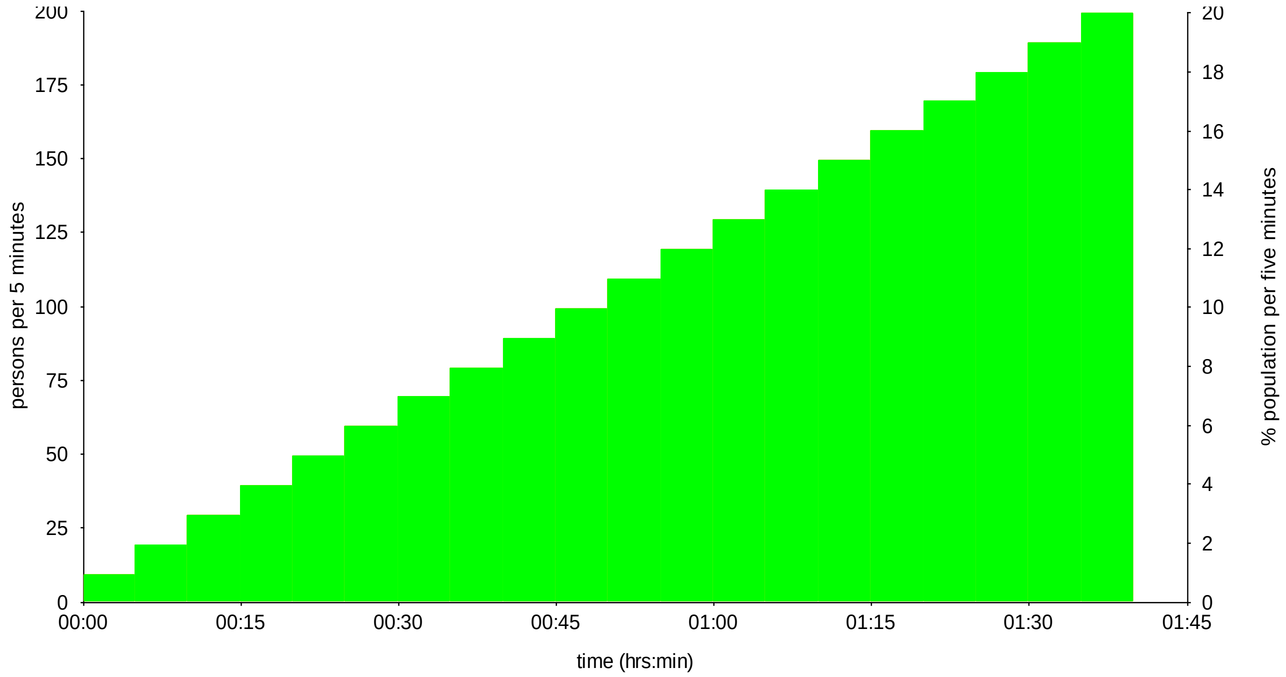

**Figure 2 Uppeak passenger demand (green incoming, interfloor yellow, outgoing red)**

The building has a population of 1000 people over 12 floors. The lift configuration is a six-car group of 1600 kg cars operating at a speed of 1.6 m/s.

By 01:10, every car is leaving the ground floor full, with the capacity factors applied such that up to 16 people load a nominally 21-person car; see Figure 3.

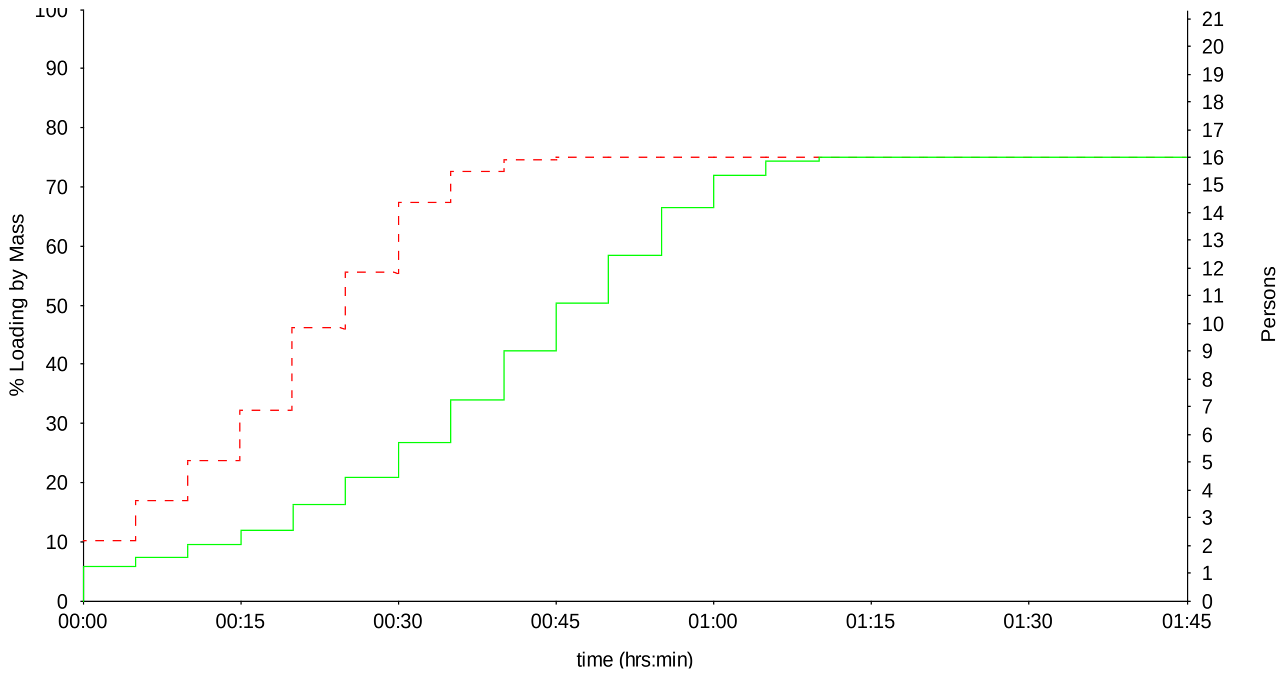

**Figure 3 Car loading on departure home floor (green average, red maximum)**

Counting the number of people loading and unloading the lift, therefore, shows the limit of the system's uppeak handling capacity. As illustrated in Figure 4, the limit of handling capacity is 133 persons per five minutes; any greater passenger demand than this gets added to the queue.

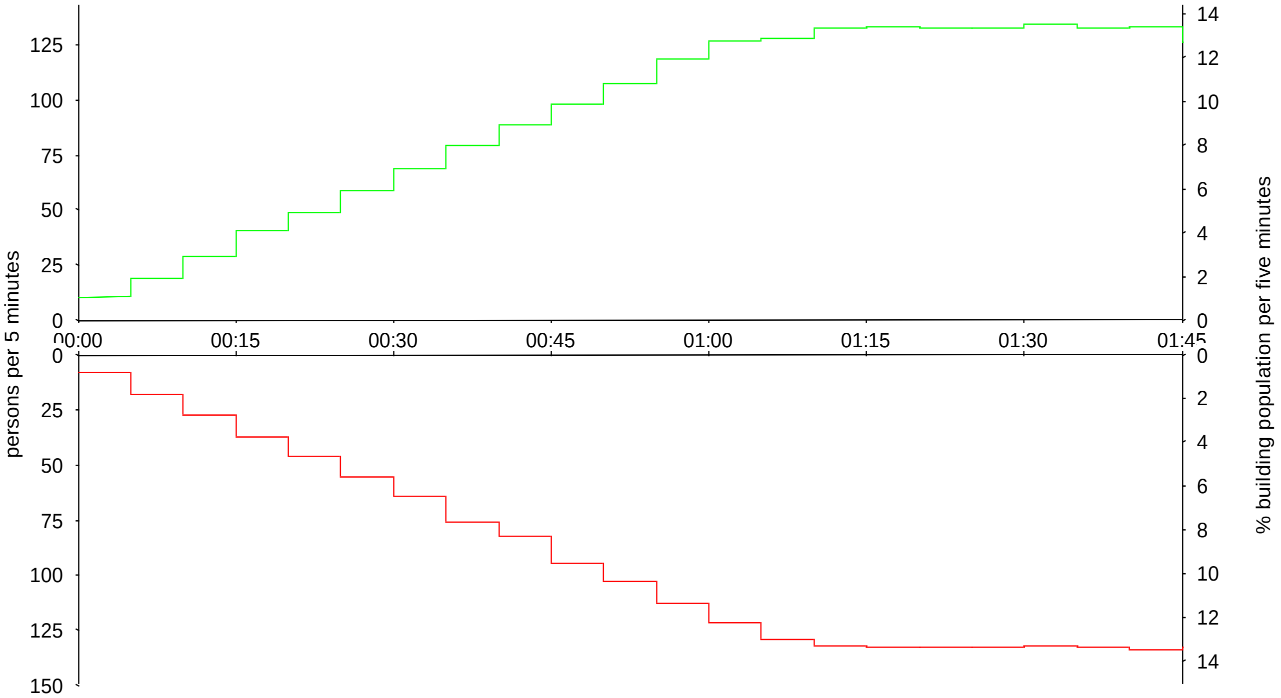

Figure 4 Uppeak passenger transfer (green loading, red unloading)

### 2.3 Down peak (evacuation) handling capacity using simulation

Now consider a down peak passenger demand, see Figure 5.

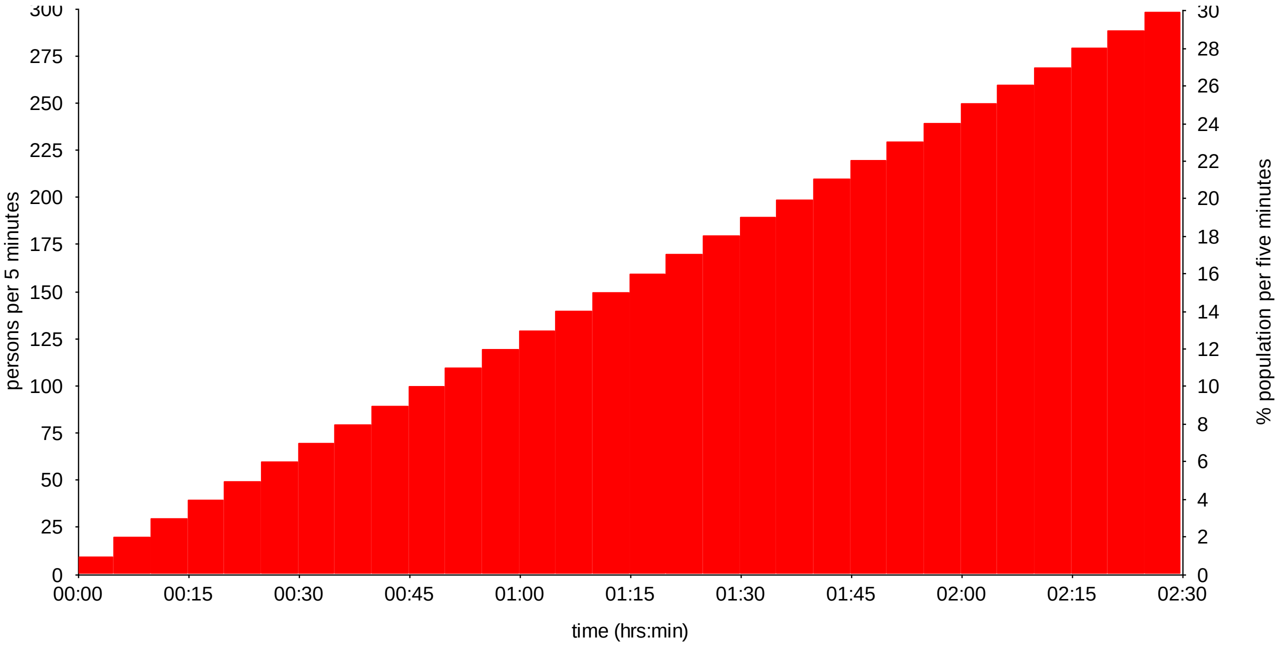

Figure 5 Down-peak demand (green incoming, interfloor yellow, outgoing red)

Applying the down-peak group collective algorithm [10], the handling capacity is 181 persons per five minutes; see Figure 6. **This is an increase of 36% over the uppeak handling capacity.**[1]

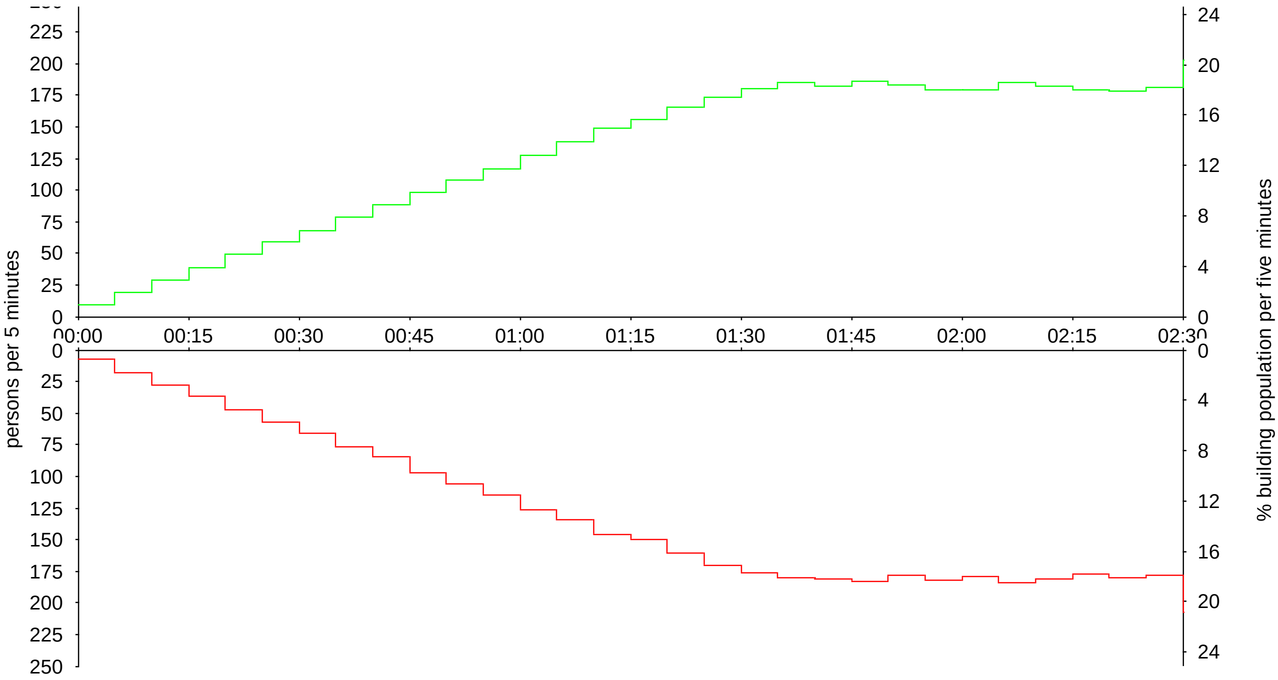

**Figure 6 Down-peak passenger transfer (green loading, red unloading)**

If people on every other floor are asked to walk down one level, the average number of stops and the average highest reversal floor can be further reduced. In the example scenario, this resulted in a handling capacity of 258 persons per five minutes, see Figure 7. **This represents a 94% increase over the uppeak handling capacity.**

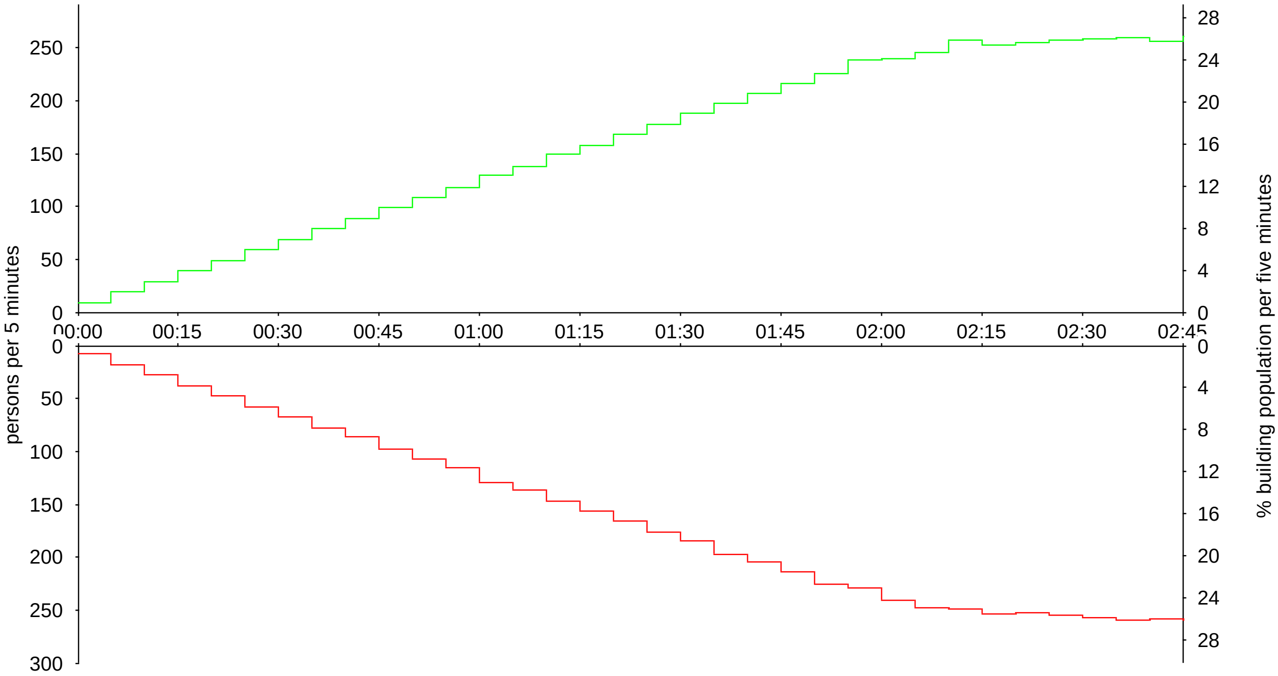

**Figure 7 Down-peak passenger with reduced stops transfer (green loading, red unloading)**

Simulations demonstrate that planning for able-bodied individuals to walk down to refuge floors, even if only a few floors, will significantly accelerate the evacuation of high-rise buildings. Asking people to walk further, thereby allowing fewer refuge floors, can maximise the additional handling capacity.

Consideration must be given to the number of floors that building occupants can reasonably be expected to walk and the lift lobby space available on refuge floors. Separate lift service from every floor will be required for those unable to walk.

## 2.4 Parallels with other dispatching concepts

As an aside, the thought processes introduced in the context of evacuation dispatching are similar to those used when discussing destination control, i.e. increasing handling capacity by reducing the number of stops and average highest reversal floor. The optimisation goals applied in destination control typically group people going to the same floors, reducing the number of stops. Consider uppeak traffic with conventional control as illustrated in Figure 8. Destination control, by grouping passengers travelling to the same destination and considering waiting and transit time, results in a reduced number of stops and a lower average highest reversal floor, see Figure 9.

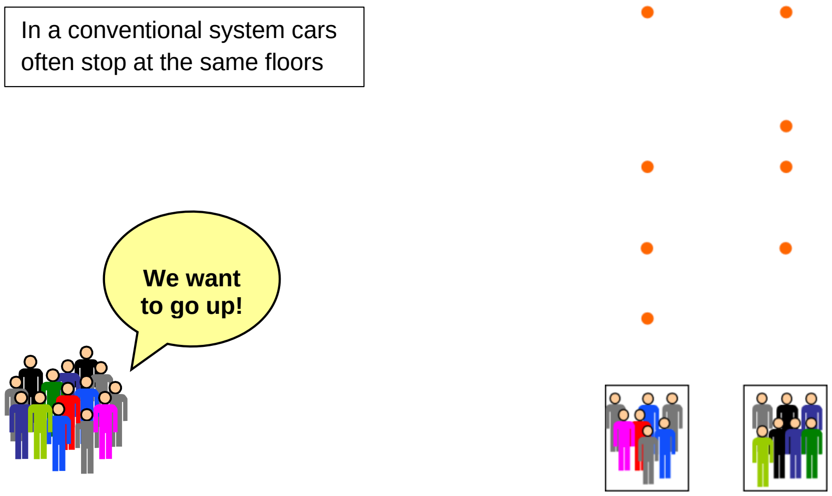

**Figure 8 Conventional control (up and down button system) during uppeak**

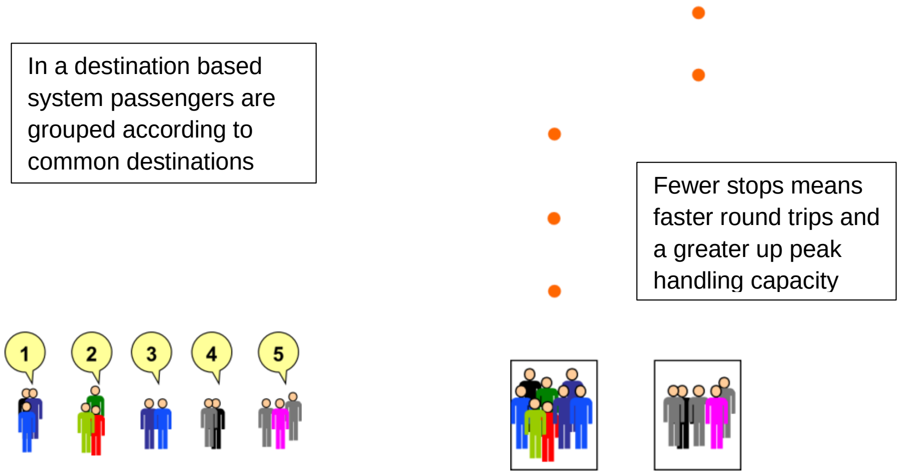

**Figure 9 Destination control during uppeak**

## 2.5 Lessons learnt

Handling capacity is related to traffic mix, i.e. the mix of uppeak, down-peak and interfloor traffic.

Handling capacity is also related to dispatching strategies. Classical dispatcher logic has been used to illustrate this. Even with intelligent dispatcher algorithms, evacuation must be explicitly considered. Dispatchers with optimisation goals to reduce waiting and transit times will differ in operation from dispatchers with an optimisation goal of maximising handling capacity.[2] The latter is what is required to evacuate a building more quickly.

## 3 RISK-BASED DISPATCHING

If a dispatcher is told the order of risk to passengers on different floors, it can be programmed to prioritise floors. For automatic operation, this requires an interface between the fire detection system and the dispatcher.

For example, if there was a fire on the 8th floor, the dispatcher could serve calls according to the priorities listed in Table 1.

**Table 1 Dispatcher priorities in case of fire**

| Floor Name | Incident | Dispatcher priority |
|---|---|---|
| Level 12 | | 4 |
| Level 11 | | 3 |
| Level 10 | | 2 |
| Level 9 | | 1 |
| Level 8 | FIRE | No call accepted |
| Level 7 | | 5 |
| Level 6 | | 6 |
| Level 5 | | 7 |
| Level 4 | | 8 |
| Level 3 | | 9 |
| Level 2 | | 10 |
| Level 1 | | 11 |
| Ground | | No calls accepted |

In this example, an assumption is made that it is unsafe for the lift to stop on level 8. However, this limitation may not be needed in some buildings, especially if there are large floor plates and the fire detection system can communicate to the dispatcher that the lifts are safely separated from the fire. In A17.1 and prEN81-76, the evacuation lifts are assumed to be protected from the fire, so the fire floor will be served.

The dispatcher would not accept calls from the ground floor as this contradicts the objective of evacuating the building. Separate firefighting lifts are assumed.

This is a generalised solution; the concept can be used to apply specific recommendations, for example, as provided in A17.1 [9] where the priority order would be (i) the fire floor, (ii) two floors above the fire floor, (iii) the two floors below the fire floor, (iv) the rest.

In the context of destination call systems, only the ground floor button would be shown on the destination input touch panel. In the context of a conventional control system, only the down-landing call and ground-floor car call buttons would be active; the car call to the ground floor is likely to be registered automatically.

Some design decisions need to be made in the dispatcher implementation. For example, if the lift is not filled at Level 9, should it travel to Level 10 and other high floors before reversing and taking a full car load to the ground floor? And if travelling down, at what threshold should the lift bypass other floors where passengers are waiting to be evacuated? Barney [1] suggests a self-evacuation touch panel, which could assist the dispatcher in supporting the dispatching algorithm to send a car when a whole car load is ready to be collected; this information could not be determined with AI analysis of video images or light curtains on the entrance to lift lobbies [14].

Even with risk-based evacuation dispatching, handling capacity can be increased by applying the strategies discussed in section 2; by asking able-bodied people to walk one or more floors, see Table 2, we can reduce the evacuation time.

**Table 2 Dispatcher priorities with increased handling capacity**

| Floor Name | Incident | Dispatcher priority |
|---|---|---|
| Level 12 | | No call accepted |
| Level 11 | | 2 |
| Level 10 | | No call accepted |
| Level 9 | | 1 |
| Level 8 | FIRE | No call accepted |
| Level 7 | | 3 |
| Level 6 | | No call accepted |
| Level 5 | | 4 |
| Level 4 | | No call accepted |
| Level 3 | | 5 |
| Level 2 | | No call accepted |
| Level 1 | | 6 |
| Ground | | No calls accepted |

## 4 USER INTERFACES

Longer-than-normal wait times for many will be necessary for the most efficient evacuation, as the dispatcher should minimise risk and total evacuation time rather than individual waiting times; reducing stops per round trip increases handling capacity at the expense of waiting time. Lower-risk floors are likely to be evacuated last.

The lifts must operate differently to evacuate a building as quickly as possible, and good communication with waiting passengers is essential. The challenges faced include:

1. Stress caused by alarms sounding and an emergency being announced.
2. Queues and long waiting times due to high passenger demand.
3. An unfamiliar lift operation mode.
4. Passengers on low-risk floors feeling left behind.

Without effective communication, there is likely to be heightened anxiety and a loss of trust. Having fire marshals guide the evacuation will support this. Still, the author believes the lifts should operate automatically and provide all the necessary guidance in case a fire marshal is unavailable.

Useful things for lift displays to indicate include:

1. The lifts are operating in evacuation mode
2. An estimated wait time for the floor to be served
3. Guidance walking down to a nominated refuge floor for faster service

Regular evacuation drills will support the most effective evacuation strategy in emergencies.

Effective user interfaces are crucial in lift evacuation strategies, ensuring that building occupants are informed, reassured, and guided appropriately during emergencies. The design of these interfaces must address the need to communicate essential information rapidly while also maintaining occupant trust throughout the evacuation process.

### 4.1 Real-Time Status Information

A key component of a successful user interface is the provision of real-time status information. Occupants waiting for evacuation lifts must be kept informed about the lift's status, such as expected wait times and operational status. Research has shown that uncertainty and anxiety are significantly reduced when occupants receive clear and timely updates, including countdown timers or queue positions [15]. Moreover, studies indicate that as the height of the floor increases, so does the willingness of occupants to use lifts during an evacuation [16]. This underscores the importance of providing detailed and reassuring information, especially for occupants on higher floors who may be more inclined to wait for a lift rather than using the stairs.

### 4.2 Visual and Auditory Cues

In addition to textual information, using visual and auditory cues is essential to attract attention and convey critical messages effectively. Bright, high-contrast signs paired with flashing lights can significantly improve visibility and comprehension, especially in low-visibility conditions such as smoke-filled environments. Green flashing lights have been shown to effectively guide occupants towards exits and could similarly be used to direct them towards evacuation lifts [15]. Additionally, auditory signals should accompany visual cues to ensure that individuals with sensory impairments are also adequately informed.

### 4.3 Addressing Psychological Factors

The psychological impact of waiting during an evacuation cannot be overlooked. Anxiety tends to make waits seem longer, especially in uncertain or high-stress situations. User interfaces must therefore provide explanations for any delays, coupled with reassurance that the lift system is still functioning as intended. Simple, credible messages from recognised authorities, such as building management or the fire brigade, can enhance trust and compliance. For instance, a message could state: "This is [Building Manager]. The next lift will arrive in [X minutes]. Please wait here or use the nearest stairway if you prefer." This is particularly important for occupants on higher floors, who, as noted, are more likely to opt for lift evacuation [15] [16].

### 4.4 Role of Lift Evacuation and Fire Marshals

The standards A17.1 [9] and prEN 81-76 [5] describe the implementation of automated lift evacuation systems designed to commence immediately after a fire has been detected. These systems allow for self-evacuation by building occupants, reducing the reliance on manual coordination. However, the role of lift evacuation and fire marshals remains critical. Fire marshals are responsible for overseeing the evacuation process, ensuring that lifts are operating correctly, and that occupants are following the correct procedures. They provide an additional layer of safety by monitoring the situation, managing any potential issues with the lifts, and assisting occupants, particularly those with disabilities or those experiencing difficulties. Fire marshals also play a vital role in coordinating with emergency services, ensuring that the lift systems are used effectively while preventing congestion and confusion in the evacuation zones.

### 4.5 Inclusivity and Accessibility

User interfaces must be designed with all occupants in mind, including those with disabilities. This includes providing instructions in multiple formats—visual, auditory, and tactile—so everyone receives the necessary information. For example, tactile signs and Braille should be used alongside visual displays to ensure that visually impaired individuals are not excluded from receiving critical evacuation instructions.

### 4.6 Testing and Drills

The effectiveness of these user interfaces should not be assumed; they must be tested regularly through evacuation drills. Testing ensures that the messages and interface elements are clear, effective, and understood by all building occupants. Regular drills also help familiarise occupants with the emergency procedures, reducing confusion and improving overall evacuation efficiency.

By integrating these elements into the design of lift user interfaces, we can significantly enhance the safety and efficiency of high-rise building evacuations. These strategies align with the best practices and highlight the increased willingness of occupants on higher floors to use lifts during evacuations [15] [16]. Additionally, the role of fire marshals, as supported by the A17.1 and prEN 81-76 standards, is crucial in ensuring the smooth operation of automated evacuation systems and the safety of all building occupants.

## 5 CONCLUSION

This paper highlights the importance of optimising lift dispatcher strategies for emergency evacuations. Traditional lift systems, designed for normal passenger flow, fall short in high-demand scenarios such as evacuations. By leveraging round-trip time calculations and classical dispatcher strategies, this study has demonstrated methods to significantly enhance lift handling capacity during emergencies.

Key considerations include the effectiveness of planning for able-bodied individuals to walk down a few floors to refuge areas, thereby improving overall evacuation efficiency. Further life-saving options include risk-based evacuation strategies prioritising floors based on risk levels.

Introducing new user interfaces is also essential to communicate effectively with passengers, reducing anxiety and maintaining trust during evacuation.

These insights underscore the need for ongoing development and implementation of advanced evacuation strategies and technologies. As building designs and standards evolve, incorporating sophisticated evacuation lifts and user-friendly interfaces will be paramount in ensuring the safety and swift evacuation of high-rise buildings during emergencies. This study provides insights for future research and development in building safety and emergency management.

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## BIOGRAPHICAL DETAILS

Richard Peters has a degree in Electrical Engineering and a Doctorate for research in Vertical Transportation. He is a director of Peters Research Ltd and a Visiting Professor at the University of Northampton. He has been awarded Fellowship of the Institution of Engineering and Technology, and of the Chartered Institution of Building Services Engineers. Dr Peters is the principal author of Elevate, elevator traffic analysis and simulation software.

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[1] The down-peak group collective algorithm is a simple but transparent algorithm, which is why it has been used for this illustration. Intelligent control systems [12] [13] increase handling capacity in different ways, but ultimately, the outcome of their algorithms is to reduce the number of stops. If there is a reliable way of knowing the number of people waiting on the floor, an intelligent evacuation algorithm can be optimised further [11].

[2] In its most basic form, a dispatcher with an optimisation goal of maximising handling capacity prioritises reducing the number of stops per round trip over longer waiting times, even if calls are bypassed on several round trips.