

WHITE PAPER

# PEOPLE FLOW AND AUTOMATED TRANSPORTATION WITH HOSPITAL ELEVATORS

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## ABSTRACT

Hospitals are one of the most complex environments for which to plan vertical transportation for fluent traffic handling. There are several needs for transportation: people, beds with nurses, and goods. In principle, separate elevators should be reserved for designated purposes. In modern hospitals, the transportation of goods, food, linen, supplies and trash is arranged with automatically guided vehicles using elevators on their journeys. Consequently, the need for manual labour and transportation devices decreases. In elevators, the destination control system increases the handling capacity so that more people can be transported with an elevator group. With destination control, the number of elevators may be decreased. Modern control systems and elevator machinery also bring savings in energy consumption. In this article, people and goods-flow handling with elevators as well as other features of modern elevator technology are discussed.

## 1 INTRODUCTION

Elevators are crucial for transportation within a hospital. There are often separate elevators for different purposes. Hospital staff and visitors need elevators to transport them to the patients' floors. The number of visitors and visiting times vary depending on the culture in different countries. Usually 1.0–3.0 visitors and 1.5–3.0 employees per bed are assumed when planning elevators. Elevators are planned to be able to transport all passengers up in less than 40 minutes. The passenger elevators use a collective control system. The calls given by the passengers at landing floors are continuously allocated. Collective control searches for the nearest car to serve the call on the way up or down. The call is finally reserved for a car at the stage the elevator starts decelerating to the floor. Several landing calls can be served during an up or down trip.

For bed transportation, the elevator car dimensions are sufficiently large so that it is possible to transport a bed. Typically, the car is 1 800 mm wide and 2 700 mm deep. Bed elevators are normally planned so that 25–50 % of all beds can be transported within an hour. In case of a bed call, an elevator is changed to bed service mode. One bed call is served at a time, and new bed calls are set in a time queue where the oldest call is served first (Interconnected Queue Control System). If the elevator were serving passengers at the time of a call, it would transport all passengers to their destination floors first. In the hospital emergency service mode, the elevator is brought to the emergency floor as quickly as possible. If the emergency elevator is occupied at the moment of a call, it is stopped at the nearest floor to allow passengers to exit before it is sent to the emergency floor.

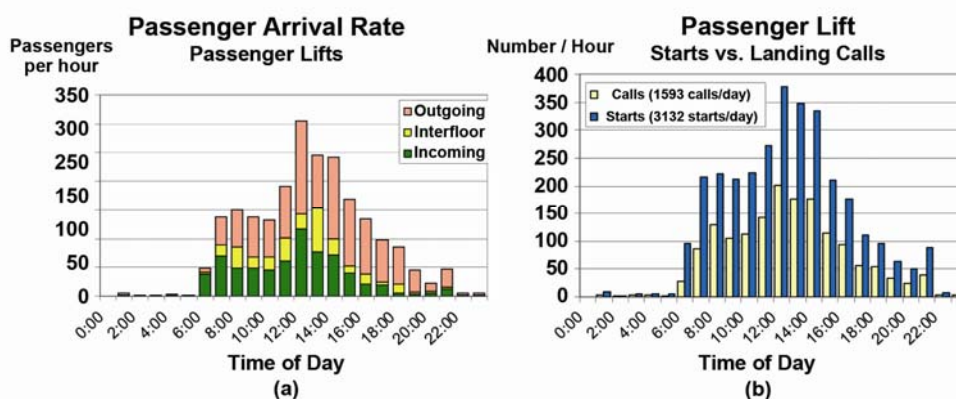
In the Nordic countries, variable duty lifts were installed in hospitals [1]. Depending on the demand, the same elevators could serve either the bed or the passenger calls. Bed calls had higher priority. Often bed calls were ascertained with a metal sling in front of or inside the car. In variable duty mode elevators, two elevator utilizations were combined, and fewer elevators were needed. A special group of 16 elevators with four passenger and 12 bed elevators was implemented in a hospital in Copenhagen. Eight bed lifts were variable duty lifts. Bed and passenger calls had separate call buttons. A bed call was given from a board that immediately showed the serving car to the user. A car call had to be given inside the car, and the car would serve one bed call at a time. Although destination bed call was not given this was an approach towards destination control.

The first applications of the destination control systems (DCS) were implemented in the 1960-70s in Australia and in a hospital in Sweden. The relay elevator controls allocated the destination calls to cars. The control system immediately showed the car that would serve the destination call. Upon arrival of the allocated car to the landing call floor, the destination calls were transferred as car calls inside the car. The car call panels were located inside the cars. Besides these applications, destination control was not

implemented for 20–30 years. Starting from 1990, an increasing number of DCS controls have been implemented, mostly in office buildings. With modern computer technology, the interface between the users and the control system has become simpler to use, and people are ready to use destination keypads that are already familiar from other applications, such as telephones. Modern DCS controls gather people with the same destinations in the same car, which reduces the number of stops and increases handling capacity especially for incoming traffic.

## 2 PEOPLE FLOW AND BED TRANSPORTATION

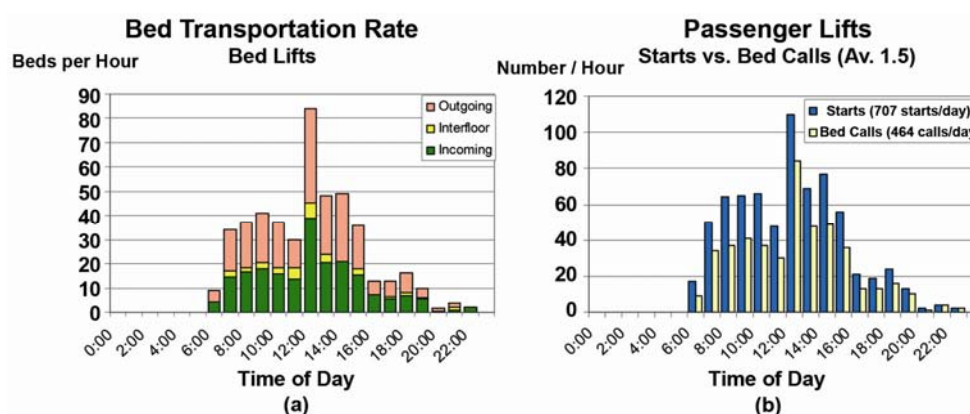
People flow and elevator performance have been measured in several Nordic countries, and in Belgium, France and Italy. Figure 1 shows the measured statistics of a triplex group serving 15 floors in Tampere University Hospital, Finland, where both visitors and staff use these elevators. Figure 1a shows the number of passengers using the elevators at different times of the day. The people flow was measured by counting the door photocell signals. The measured traffic pattern is divided into incoming, outgoing and inter-floor components. Most of the lift users enter or exit the building, and about 20% of passengers comprise inter-floor traffic between the floors. In this hospital, passengers use the elevators from 06.00 to 22.00, in total 16 hours a day. The traffic is heaviest between 12.00 and 15.00 with 250–300 persons per hour. Measured starts and passenger landing calls are shown in Figure 1b. There are, on average, about twice as many starts as there are landing calls. Landing calls are collected and there may be several persons inside a car during an up or a down trip. The time from one start to the next one (cycle time) varies between 20 and 25 seconds, with a stop time of about 10–15 seconds. According to the measurements, the visitor elevator starts 400–1 600 times per day. Based on these figures, it can be estimated that there are 150 000–550 000 starts per elevator within a year.



**Figure 1. People flow - incoming (green), outgoing (red) and inter-floor (yellow) - components (a), and starts and landing calls per hour (b) of a triplex passenger elevator group**

Another example is from the eight-floor Central Hospital in Hämeenlinna, Finland. A triplex elevator group is for bed transportation. Bed traffic occurs

mainly between 06.00 and 22.00. The traffic is more or less two-way, consisting of incoming and outgoing components (Figure 2a). With bed elevators, the stop time is longer than with passenger elevators, typically 20 seconds and the cycle time lasts for 30–35 seconds. Each bed call causes about 1.5 starts, making 240–580 starts per elevator during one day (Figure 2b), which makes 80 000–200 000 starts per year.



**Figure 2. Bed traffic transportation rate (a) and starts per bed call (b) are shown for a triplex bed elevator group**

### 3 DESTINATION CONTROL IN HOSPITALS

The efficiency of bed transportation cannot be increased with a destination control system, but immediate elevator announcement and displays give patients and beds extra time to approach the serving elevator. With a destination keypad, there is no longer the need for several keys to be used to call for elevators for different modes as earlier. The access rights to enter and exit floors for patients and visitors can be restricted.



**Figure 3. Destination control system in hospital surroundings**

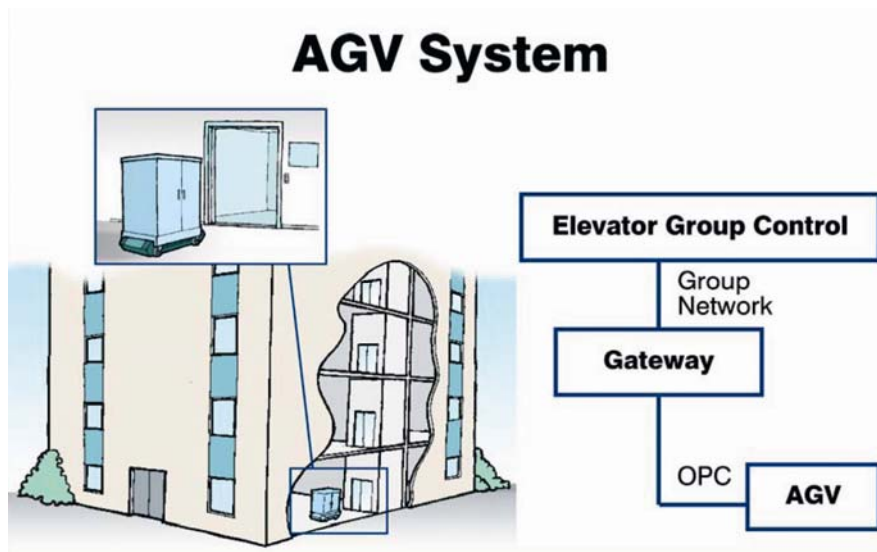
Doctors and nurses can be entitled to give bed calls or hospital emergency calls with a destination keypad. Variable duty lift modes can be applied without keys or metal detectors, as used in earlier control systems. Elevator service personnel, firemen and others with special demands can be given access rights to take a car in use, e.g. with a special code. Visitors can obtain a card from the reception, which gives the destination call only to a pre-defined floor. Exiting to the main entrance of the building is allowed without a card. In this way, a visitor using an access card that automatically registers the destination call does not have to be aware of other hospital floor functions.

The guidance of passengers is improved with modern displays that can show information of the elevator and building status. The destination keypad shows the serving elevator and its location; lobby displays show, e.g. elevator indications and calls, and tenant occupation; inside the car all stops, position, direction of the car are shown as well as other services, such as news and weather. It may even be possible to show the whole passenger route from the entrance to the destination.

#### 4 AUTOMATED GOODS TRANSPORTATION

In hospitals, separate elevators are needed for service, food, linen, and medical supplies and goods transportation. In modern hospitals, automated vehicles can be used instead of employees. Some companies produce Automated Guided Vehicles (AGV). Usually they offer an interface for elevator manufacturers to use. Elevators and AGVs communicate through a gateway using, for example OPC (OLE for Process Control) interface as shown in Figure 4. When an automated vehicle arrives at an elevator lobby, the elevator control receives a signal from the AGV system and sends a car to the floor. The elevator is in a special AGV mode throughout the vertical trip until the vehicle leaves the car. AGV transportation logistics can be scheduled so that the elevators are used during light traffic hours, for instance at night time. The transportation capability of elevators is therefore also utilized efficiently.

In addition, other building safety systems, such as access control, fireman's control and security centre can be connected to elevator control through the gateway and the OPC protocol.



**Figure 4. AGV and elevator interface**

## 5 LATEST ELEVATOR TECHNOLOGY ACHIEVEMENTS

Modern elevator technology requires less space than e.g. ten years ago. With destination control, the number or size of staff and visitor elevators can be decreased. Several user groups, such as beds, staff, and visitors, can use the same elevators. The Permanent Magnet Synchronous Motor (PMSM) innovation decreased the elevator machinery size dramatically [2]. With low speeds the motor can be located in the elevator shaft, which eliminates the need for a machine room. With higher speeds though, a small machine room is needed, but even with the high-speed elevators, the machinery is much smaller compared to the technologies used before 2000.

PMSM with regeneration decreases energy consumption up to 40% compared to older motors. In addition to this, a modern group control system with multi-objective optimization can dispatch elevators so that a desired balance between energy consumption and waiting times can be achieved [3].

One of the latest innovations to reduce space is with machinery that does not use any counterweight at all. Either the shaft sizes can be decreased, or with fixed shaft sizes the elevator floor area becomes larger, which improves the accessibility of beds and wheelchairs in the cars.

## 6 CONCLUSION

In hospitals, two to three times heavier passenger arrival rates in elevators have been measured compared to bed transportation rates. Modern elevator technology brings several advantages compared to the technologies that were used 10–15 years ago. Control systems are more efficient and flexible than they used to be, so too are the methods used to guide passengers. Elevator hoisting systems have evolved so that space and energy can be saved. Elevators can be connected to other building systems and logistical systems

successfully. Some of these technologies are quite new and it will take time to see them in operation in real hospital surroundings.

The trend in patient care shows that patients stay in hospitals for a shorter time than before, and patients are not confined to bed for as long as some years ago. Food will not be distributed up to the wards but passengers will eat in restaurants. The turnover of patients will be greater and there will be more patient trips to and from restaurant floors. This will bring challenges to many practices. In elevator planning new trends will increase traffic demand, which should be taken into account when planning elevators in hospitals.

## REFERENCES

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