The planning and performance of groups of elevators

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Foreword by the author.

Chapter 1: Planning groups of elevators for tall buildings

Summary: Elevator planning must satisfy two conflicting demands:

1. Groups shall occupy the least possible building space to maximize rentable areas.
2. Groups must provide best possible service qualities under all traffic conditions.

These two demands define a single problem: the efficiency of elevator operations. This efficiency is primarily defined by building/elevator planning and secondly by elevator group controls. This book explains why and how "intelligent destination" group controls will enable best-possible planning and best-possible service qualities under all traffic conditions.

Chapter 2: Population and traffic density patterns

Summary: The monitoring and recording of traffic and performance data is a permanent activity of "Intelligent destination" group controls and the basis of their learning abilities. This chapter shows a method to visualize population- and traffic density patterns in a format that allows the statistical analysis of traffic patterns. The data from analysis will facilitate reasonably accurate traffic predictions. Population- and traffic density patterns are also of great interest for building managers and owners. Know-how of populations and traffic flows in existing buildings is essential for planning new buildings.

Chapter 3: Elevator “muscle power”

Summary: Elevator "muscle power" controls how swift a car can move between floors including the times for closing and opening of doors. Door to Door Flight Times (DDFT’s) define the "muscle power" of each elevator. DDFT’s can be measured easily and facilitate the comparison of the "muscle power" of different types or brands of elevators.

Chapter 4: Elevator "brain power"

Summary: The term "brain power" or “brains” is used to designate all control components of a group. The origins and features of "collective selective" and "destination" group controls are briefly described.

Chapter 5: Traditional elevator planning

Summary: The planning of "collective selective" (traditional) elevators is ruled by the following maxim: When a group of elevators can satisfy the maximum arrival rate of passengers during UP PEAK traffic their performance under all traffic conditions will be alright. This maxim implies that building planning, i.e. the configuration of traditional groups is based on their UP PEAK performance. Consequently the planning of traditional groups is very simple and inflexible. This chapter discloses that the method of elevator planning on the basis of so-called traffic calculations is flawed. The calculated data provide misleading information about the performance potential of traditional groups.

Chapter 6: Average Waiting Time (AWT), the misleading parameter

Summary: The AWT parameter of traditional UP PEAK "traffic calculations" for "collective selective" elevators gives a misleading impression of the quality of elevator services because the AWT calculation method is unrealistic. Comparisons of 4-car and 6-car groups with large cars show that 6-car groups are particularly inefficient cost much more and deliver service qualities that are worse than those of 4-car groups. Graphs of the Waiting Time Bandwidth (WTB) can disclose the true quality of AWT's of any group, with any group control and for any traffic period.

Chapter 7: Why "intelligent elevators" perform better

Summary: This chapter explains why and how "Intelligent destination" group controls enable best-possible performance. Understanding the purpose of "selected floors" patterns, the data structures enabled by the patterns, the artificial experience system and the new method for performance calculations will help to appreciate the data and logic of the following chapters.

Chapter 8: Planning "intelligent elevators"

Summary: Elevator planning is a search for the best-possible compromise between several interdependent and conflicting considerations. Its objective is defining the best-possible building plan / group configuration for a specific project that delivers transport capacities and time-dependent service qualities for a defined range of traffic conditions that can be contractually guaranteed. The required building volume shall be as small as possible to maximize rentable areas. Capital-, maintenance- and energy costs shall be as low as possible. "Intelligent destination elevators" enable the best-possible compromise for any building because "Intelligent destination" group controls can simultaneously control the efficiency and the service qualities of any group under all traffic conditions.

Chapter 9: Artificial experience system

Summary: A group of intelligent destination elevators must accumulate "artificial experience" to make reasonably accurate predictions of traffic conditions for the next 5 minutes. These data enable setting the permitted numbers of stops and performance targets at the start of each UP or DOWN trip. Monitoring, recording and analysis of traffic data will yield patterns of the behavior of the building- and floor populations that provides this experience. The correlation between predicted- and momentary conditions enables the sensory abilities of the group control system. Monitoring supports the building management information system with data of traffic densities, floor populations, elevator service qualities etc.

Chapter 10: Traffic simulation

Summary: Traffic simulation will support the planning of intelligent destination elevators and enable contractual guarantees for service qualities. The guaranteed service qualities can be validated by the group itself after completion. Traffic simulation shows to building planners the consequences of their decisions in terms of service qualities for various traffic conditions. Traffic simulation is possible for any group of elevators and enables exact performance comparison of identical groups, i.e. comparison of group control systems from different suppliers, on the basis identical artificial traffic conditions. The group control system that delivers best-possible performance under all traffic conditions is likely to become the future standard system.

Chapter 11: Communication with passengers, building security and intelligent door- and drive systems

Summary: This chapter reviews a few aspects of group controls that deserve special attention during the development of "intelligent destination" group controls.

Chapter 12: Express elevators to Sky lobbies

Summary: Express elevators are the ultimate destination elevators. With Double- or Triple-Deck cars express elevators can transport large numbers of passengers through one set of hoistways. Sky lobbies contribute to the economic value of a building in two ways: the value of the additional floors enabled by express elevators and the value of the Sky Lobby itself. Planning concepts for buildings with one and two Sky Lobbies are reviewed.

Chapter 13: Transparent performance calculations

Summary: Traditional “traffic” calculations determine the average Round Trip Time (RTT) and other UP PEAK performance parameters of "collective selective" elevators. This chapter introduces a new method for performance calculations that makes these calculations transparent and checkable. Two new parameters are introduced: Average Travel Time in the Car (ATTC) and Average Time To Destination (ATTD) that enable new insights into the quality of elevator services.

Chapter 14: Patterns for "selected floors"

Summary: Patterns for "selected floors" are the basis of the Comparative Performance Tables (CPT’s) that have been used in previous chapters to demonstrate the performance potential of intelligent destination elevators for UP traffic. This chapter proves with "selected floors" patterns that a group can vary transport capacities and distribute transport capacities evenly over all floors whilst maintaining a best-possible balance between transport capacities and time-dependent service qualities. Time-dependent service qualities are improved by the "First come first served" method of service call assignments to specific cars.

Chapter 15: "Selected floors" module

Summary: For each "selected floors" pattern we can calculate a data table for UP traffic with averages for RTT’s L & H, Cycle RTT’s, DC5’s and all other service qualities for a range of numbers of passengers in the cars. The "selected floors" module is a section of the calculated data structure that consists of all data tables for all "selected floors" patterns that are relevant for a specific group. The "selected floors" module enables making Comparative Performance Tables (CPT’s) that show how different patterns (options) can satisfy specific UP traffic conditions. Service quality graphs give a “picture” of any CPT that is easier to “read” than the CPT itself.

Chapter 16: Module for heavy simultaneous UP and DOWN traffic

Summary: Each data line of a "selected floors" data table can be extended with for assumed numbers of additional stops and passengers during the DOWN trip and the corresponding data. This method enables creation of an extended data table for any "selected floors" pattern. The module for heavy simultaneous UP and DOWN traffic consists of extended data tables for all patterns that are relevant for a specific group. A complete module may consist of many thousands of data lines; however, this chapter will show that a complete module is of little importance. This module enables "Intelligent destination" controls to select the permitted number of stops or direct-trip modes of car operations for heavy traffic conditions.

Chapter 17: Module for moderate traffic conditions

Summary: During moderate traffic conditions high transport capacities are not required and intelligent destination group controls can concentrate exclusively on best possible time-dependent service qualities. These will be achieved when the INTERVAL between cars is as short and as consistent as possible. Minimizing the number of stops is essential for shortest-possible RTT's, INTERVALS and AWT's. This implies that too-short waiting times must be avoided. This chapter presents the module for moderate traffic conditions in a matrix format. The 3-dimensional format for calculated data structures will probably be attractive when intelligent destination controls are developed.

List of abbreviations / definitions