Chapter A: The dilemma of the elevator industry

The main problem of tall buildings

During periods of heavy traffic, the groups of elevators serving tall buildings deliver their worst performance. The obvious cause of this problem are large cars, which make too many stops, to distribute or collect their large contract loads. Groups with large cars are inefficient.

The hidden cause of this inefficiency is the lack of theoretical knowledge in respect of the planning and performance of groups of elevators. This knowledge was not relevant during the early 1900's because elevator supervisors and attendants, who knew the destinations of passengers and the necessity to make as few stops as possible, assured the efficient operation of groups. When during the 1950's supervisors and attendants lost their jobs, elevator companies faced an apparently insolvable problem: The coordination of car operations without supervisors and attendants. This problem was resolved 50 years later, when the author discovered the inherent relativity of group characteristics. This discovery disclosed the optimal performance potential of groups, and facilitated the development of intelligent group control systems, which make the performance of groups predictable and controllable. These systems facilitate optimal group performance in conjunction with direct communication with each passenger.

Apparently, elevator companies have decided the optimal performance of groups is not in their best interest, because it will affect competition for new buildings and maintenance services for existing groups. Elevator companies continue to promote groups with proprietary controls, with false performance claims, misleading and incomplete information, and outdated planning methods. Contractual guarantees for best possible performance and optimal efficiency are not possible for groups with proprietary controls, which do not comply with the inherent relativity of group characteristics. Consequently, the planning and installation of inefficient groups in new buildings continues, as will be proved in the further chapters of this book. The controls of existing groups are not improved. This peculiar situation is the dilemma of the elevator industry.

This chapter outlines the facts and circumstances, which are the cause of this dilemma, to put this matter in perspective. These insights and know-how of the planning and performance of groups will enable building owners, architects, and consultants, to make planning decisions on the basis of relevant efficiency and performance data, which can be contractually guaranteed.

Elevator group controls

An elevator is a simple device; however, a group of elevators presents a complex problem: Optimal group performance requires the exact control of cars under all traffic conditions. The moving cars of a group should be optimally spaced, as if connected by an invisible string that optimizes their positioning. Intelligent destination group controls based on the inherent relativity of group characteristics facilitate the best possible positioning of cars.

During the 1960's Mr. Leo Weiser Port (†1978) had the brilliant idea to move the floor buttons in the cars to the landing boards (lobby panels), to enable passengers to register their destinations, and the group control to assign passengers to specific cars. This innovation implied the problem of the erratic control of cars by floor buttons in the cars, i.e. the random destinations of passengers, was resolved. Mr. Port realized the first such group in a government building in Sydney Australia (late 1960's). Unfortunately, this group, with a relay control, was not successful.

During the second half of the 1980's the Schindler group re-introduced destination group controls based on modern technology. These controls were successful and almost immediately adopted by all leading elevator companies. They became the preferred control system for tall buildings.

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The present generation of *proprietary* destination group controls apparently do not comply with the natural laws of the inherent relativity of group characteristics, i.e. are not intelligent, and cannot deliver optimal performance.

In this book, the term "intelligent controls" means intelligent destination group controls. The term "intelligent groups" stands for groups with

intelligent controls. Intelligent groups communicate direct with each passenger via their mobile phones or alternative systems. Consequently, the group control has exact data of all momentary transport requirements and can inform each passenger of the specific car assigned to his/her requirement. Lobby panels may be used but are not essential.

The inherent relativity of group characteristics

The performance of groups of elevators is a multi-dimensional problem in which time is the decisive dimension. Time "costs" control all aspects of group performance, because each stop causes a great loss of time. Cars must slow down and stop, doors open, passengers go in and/or out, doors close, cars must start and accelerate. These time costs explain why control of a single parameter defines all group service qualities and characteristics. This parameter is the total number of *permitted stops* during each round trip. The total of momentary up and down traffic densities defines the number of permitted stops. The logic of this solution is obvious: Unnecessary stops increase round trip times causing worse group performance.

To prove that the relativity of group characteristics is *inherent* is just as simple: A two-car group will be far more efficient than one large elevator. Each car of a two-car group can be *more than 50 % smaller* than one large car, because during identical traffic conditions each smaller car makes fewer stops. The better efficiency and increased transport capacities of groups with more and smaller cars improve all group service qualities. Each time the number of cars of a group is increased, the cars can be smaller, transport capacities and time-dependent service qualities are improved. and the number of floors served can be optimized. This logic does not depend on group control systems. It is an inherent characteristic of groups of elevators.

The configurations of groups are decisive for group efficiency in respect of space- and energy requirements. Intelligent controls are decisive for optimal car operations, i.e. time-dependent service qualities and transport capacities.

The Appendix of this paper proves the inherent relativity of group characteristics also applies for groups with non-intelligent controls.

Innovations and features of intelligent groups

Intelligent controls facilitate the exact planning of group configurations, which deliver specific service qualities in combination with minimum space- and energy requirements. After conversion to intelligent controls, any existing group will deliver its <u>group specific</u> optimal service qualities.

During all traffic conditions, intelligent groups minimize and equalize round trip times by minimizing and equalizing <u>the permitted number of stops for each roundtrip</u>, based on the total of momentary up and down traffic densities. The up and down segments of round trips are allocated their permitted number of stops, pro-rata to momentary up and down traffic densities. These methods imply round trip times and all time-dependent service qualities are always the shortest possible.

Their average values in seconds will be highly consistent. At all times, up and down transport capacities are maximized and momentary carloads minimized.

The permitted numbers of stops for each round trip is determined by assessing a group specific data structure, which comprises all calculations for all possible round trips and all possible numbers of passengers, i.e. carloads. The calculated data structure make the relationship between numbers of stops and transport capacities, i.e. traffic densities, transparent.

Data structures are the artificial experience systems of intelligent groups. They can instantaneously provide all modes of car operations, i.e. the permitted number(s) of up and down stops and carload(s), which will satisfy a specific combination of up and down traffic densities. This implies all group performance data are **predictable** and are available during the planning of groups.

An intelligent group activates a second “recorded data structure” after installation. The recorded data structure uses data “learned” from the analysis of group operation records instead of calculated data. The recorded data structure does not replace the calculated data structure, i.e. an intelligent group has two data structures, which enable comparisons of calculated and real performance data. The real data will usually be slightly better than the conservatively calculated data. These systems and methods explain why the performance and efficiency of intelligent groups enable contractual guarantees. During the planning of groups, traffic simulation facilitates confirmation of calculated data, i.e. to predict the data of the recorded data structure.

Intelligent groups enable a whole range of additional innovations: *Intelligent building management and information systems*, improved building security and automation systems etc. New group configurations based on double-, or triple-deck cars, which simultaneously serve to two or three “Layered Zones”, will enable extremely tall buildings, which combine minimum space requirements and outstanding service qualities and transport capacities.

Why do elevator companies ignore the inherent relativity of group characteristics?

The adoption, i.e. the introduction, of intelligent group controls implies the standardization of group controls. Elevator companies apparently consider this development to be a disruptive innovation, because it ends the practice of claiming unique features for proprietary group controls. The performance of intelligent groups is predictable and controllable. Consequently, contractual performance guarantees will replace present methods of performance evaluation, which pretend to demonstrate good performance, however, without guarantees for optimal performance.

Proprietary group controls manage car operations with undisclosed and unexplained methods. These controls have a “black box” function, which complicates maintenance for third parties and protects the original supplier from undesirable competition.

Another reason for ignoring the inherent relativity of group characteristics may be the organization structure and business model of elevator companies, which seem to inhibit innovation. To appreciate these aspects please consider the typical history of elevator companies.

Elevator Manufacturing and Elevator Contracting cause conflicts of interest

The roots of elevator companies are the mechanical workshops of the late 19th century, which specialized in manufacturing elevators. They engaged locally in elevator contracting and soon began to appoint agents in other cities and countries. The agents were independent elevator contractors. After World War 2, elevator manufacturers and contractors were the beneficiaries of the ensuing reconstruction boom. Later manufacturers noticed the steady and growing maintenance income and profitability of their agents, whereas the profits from manufacturing were declining due to increased competition. This marked the beginning of a long period of acquisition of their agents, which by now seems to be completed.

Presently elevator contracting is the primary activity of elevator companies, because maintenance is its most profitable, and growing, activity. Manufacturing is a secondary activity, which results from contracting engagements for the supply and installation of elevators in new buildings. It is obvious that the decentralized contracting activities of elevator companies determine every aspect of their success.

The long period of acquisition of contracting activities by elevator companies, is in fact the transition of the elevator industry from a manufacturing to a contracting and service industry. Although the acquisitions are completed, the transition to a contracting industry is stagnating. This is not surprising. The conflicts of interest between manufacturers and their agents of the past are now internal conflicts of interest of elevator companies. In spite of the profound changes of their activities, these conflicts may be the cause why some elevator companies continue to operate as if they are a manufacturing organization selling hardware.

The organization structure of elevator companies

The centralized functions of elevator companies such as group management, finance, R & D, factory management, and a variety of other staff functions, are well established and played an important role during the formative years of each elevator company.

Their de-centralized contracting activities are relatively new and possibly not yet well organized or strong enough to play an active role in shaping company policies. For example: Guidance of R & D, transfer pricing of components from factories to contracting operations, subcontracting to, or purchasing of components from, third parties, and so on. These elements of company policy are of greatest importance for successful contracting. Conflicts of interest and the profitability of a *captive maintenance portfolio* may be the reasons for ignoring a major innovation potential.

Elevator consulting

When, during the 1950's, elevator attendants and supervisors were abolished, groups of elevators lost their human intelligence. During the next 30 years traditional groups, with up /down buttons in the lobbies and floor buttons in the cars, remained the industry standard. Elevator companies have tried to adapt these groups for automatic operation with zoning, neural networks, artificial intelligence, fuzzy logic, etc.; however, these efforts were not successful. Floor buttons in large cars caused high numbers of stops, efficient car operations were impossible.

During this long period of Insecurity in respect of group performance, independent elevator consultants attained the leading role in the planning of groups for new buildings. The offers from elevator contractors for groups in new buildings usually included traffic calculations and traffic simulation data, which were ambiguous and difficult to interpret. Architects engaged the services of independent consultants to evaluate these offers. Later the planning of groups with consultants, and possibly one or two elevator contractors, became a common practice. Elevator companies learned to appreciate this situation because it obscured the responsibility for group planning. Moreover, neither consultants nor elevator contractors could guarantee the efficiency and performance of groups, i.e. apparently no party was responsible for the efficiency and performance of the most important system of tall buildings, i.e. vertical transportation!

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The introduction of destination group controls by Schindler, approximately 20 years ago, did not affect the role of elevator consultants, because the inherent relativity of group characteristics was still unknown. Other elevator companies, almost immediately, introduced their own *proprietary* destination group controls. These proprietary destination group controls could not and still cannot guarantee optimal performance. Until now, this situation has not changed, because the elevator companies ignore the inherent relativity of group characteristics.

Concluding remarks

The planning of **groups** of elevators has gone astray when elevator contractors lost their influence on the planning of groups. Elevator companies accepted or tolerated to be not responsible for the efficiency and performance of groups i.e. abandoned responsibility for their most prestigious product line.

Because of this situation the design, supply and installation of inefficient groups continues. In recent years, several groups with six and even more cars and large contract loads were completed. These groups cannot be efficient because both, their incorrect configurations and non-intelligent group controls are the cause of their inefficiency.

Elevator group controls are essentially a communication problem. The group control requires knowing the destinations of all passengers. These traffic density data enables an intelligent group to decide the permitted number of stops for each round trip and to assign each passenger to a specific car. The assignment of passengers to specific cars was long ago a building management task. If elevator companies do not adopt this task, the author expects that intelligent building management systems will take back this function.

The Appendix of this chapter proves that groups with more and smaller cars deliver much better performance. The optimum contract load of a 4-car intelligent group is 1200 KG, i.e. an intelligent group also reduces energy consumption by approximately 25% and improves time-dependent service qualities. Existing 6-car groups with contract loads of 1600 KG waste approximately 50% of their energy consumption.

Existing groups cause a meaningful loss of time for millions of passengers each day.

As mentioned on page Introduction the knowledge of group performance will make the planning of groups an exact process. In the future group planning will be teamwork of architects, consultants and elevator contractors, i.e. all parties responsible for the configuration of groups and the specific service qualities these groups must deliver for projected populations. Contractual performance guarantees by elevator contractors will be a new element of group planning for new buildings.

Appendix: The inherent relativity of group characteristics also applies for traditional groups

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The table below compares two groups with traditional collective selective controls, i.e. groups with up/down buttons in the lobbies and floor buttons in the cars. Group ONE has 4 large cars (1600 KG) and group TWO has 6 small cars (800 KG). The calculated performance data are based on the probable number of stops for the assumed numbers of passengers. They disclose remarkable differences of group service qualities.

For information about so-called “traffic” calculations please refer to Chapter 5: “Traditional elevator planning”, and Chapter 6: “Average Waiting Time, the misleading parameter.

Number of cars in group	4	6
Number of floors served	13	13
Population (75 / floor)	975	975
Contract load in KG	1600	800
Contract load, maximum in persons	20	10
Contract speed in m/sec.	2.5	2.5
"Footprint" of each elevator in m^2	8.0	5.3
"Footprint" of group in m^2 •	32	32
Assumed number of passengers in the cars	16.0	8.0
Probable stops (mathematical formula)	9.4	6.2
ROUND TRIP TIME	155.7	111.7
Maximum up peak transport capacity (% of pop./5 min.)	12.6	13.2
Theoretical minimum departure interval	38.9	18.6
Theoretical minimum Average Waiting Time (AWT)	19.5	9.3
Realistic Average Travel Time in the Car (ATTC)	60.6	43.1
Average Time To Destination (ATTD)	80.0	52.4

- The “Footprints” are based on net internal hoist way areas, without allowance for separating beams, hoist way enclosures, and lobby areas.

NB:
The table demonstrates that the inherent relativity of group characteristics also applies for groups with non-intelligent controls.

The theoretical, i.e. not realistic, minimum average waiting time improves by a factor TWO. The realistic average travel time in the car is approximately 30 % shorter.

The energy consumption of the 6-car group will be at least 25 % less.

These improvements are typical for groups with configurations based on the inherent relativity of group characteristics.