Chapter G: World Trade Center, Tower 4, New York:
An example of an elevator planning disaster.

The article "4 WTC Complete" in the September 2014 issue of ELEVATOR WORLD reported the grand opening of Tower 4 of the World Trade Center in New York on 13 November 2013. This article provides detailed information of the configurations of the five groups of single-deck elevators, which serve five building zones. The article refers to: "Semantic door operators", "hydraulic interactive roller guides", "full cab mockups could be experienced before manufacturing", "detailed reviews of rail stacking", and "Port destination-dispatching technology". The article does not say one word about the service qualities that the thousands of users of WTC 4 may expect from the five groups of elevators.

The basis of Mr. Port's concepts for elevator group controls is logic, not technology. By omitting floor buttons in cars and demanding passenger to input their destinations, groups with destination controls must assign passengers, i.e. assign permitted destinations, to specific cars. **This mode of control implies that intelligent groups control the movements of each car.** Elevator companies never refer to this important aspect of groups with destination controls. They maintain strict silence about the traffic density patterns of tall buildings, i.e. *the transportation requirements of building populations*. The topics transport capacities, service qualities and the efficiency of the groups of elevators, which serve tall buildings, are taboo. A copy of the ELEVATOR WORLD article is available under downloads.

Intelligent groups manage time-dependent service qualities and transport capacities

Example: If an approaching car does <u>not stop</u> for a call, which would give a specific passenger a too short waiting time, passengers in the approaching car reach their *destinations earlier* and passengers waiting for this car benefit from *shorter waiting times*. Intelligent groups monitor how destination assignments to cars influence time-dependent service qualities. The EXCEL workbooks of this chapter prove that a reduction of one or two stops cause a modest increase of average waiting times, however the reduction of average travel times in the cars exceed the the average waiting times increase! Transport capacities increase. This feature is of particular importance for optimizing group performance during heavy traffic.

WTC 4 Zoning

WTC 4 is a "good" example of flawed group planning, because its faults are **typical for empirical group planning, i.e. planning on the basis of observation or experience without a logical theory. Moreover, empirical planning ignores the inherent relativity of group characteristics.**
WTC 4 has **FIVE** building zones; TWO 8-car groups A and B serve the lowest building zones and THREE 6-car groups C, D and E serve the high zones. All contract loads are 1600 KG. The lowest group A exclusively serves 15 floors (15-29) of WTC 4. The four groups B, C, D and E "overlap", i.e. have zone-transfer floors on levels 42, 51 and 62.

In tall multi-tenant buildings, zone-transfer floors are unusual because tenants, which require two or more floors, prefer adjacent floors in the same zone. Persons working on zone-transfer floors will use the groups, which serve their floors with direct trips to and from the main lobby. Consequently,

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inter-zone traffic is modest and NIL during periods of heavy traffic. Only group A is not "handicapped" by a zone-transfer floor.

The Appendix to this chapter shows a diagram of the FIVE existing groups and the maxima of their calculated performance data by stress tests. Group E has the longest average waiting times and longest average times to destination. Workbook "WTC-E-6cars-11flrs-existing" shows on page Recorded Data (lines 80 to 113) the maxima of the existing- and alternative groups of this chapter.

Configuration of group A

This group demonstrates the worst fault of the WTC 4 groups: The contract loads of 1600 KG are too high. They permanently waste energy and building space.
Workbook "WTC-A-8cars-15flrs-existing" proves and demonstrates on page Recorded Data, lines 41 to 74, that an 8-car group A, with intelligent controls and contract loads of 1200 KG, would have been perfectly adequate for group A. With carloads of 12 passengers group A can deliver extreme simultaneous transport capacities up to 6.1 %, in combination with optimal time-dependent service qualities. *Groups, which can deliver extreme simultaneous transport capacities, can satisfy all transport requirements of building populations*. Traffic simulation and recorded data of existing groups confirm this fact.

The 1600 KG contract loads of group A, i.e. 33 % more than the optimum of 1200 KG, increase the maximum simultaneous transport capacity by only 10 % from 5.4 % to 6.0 %. The time-dependent service qualities, cells V66:V69, disclose how high carloads and additional stops negatively affect time-dependent service qualities. The text box next to the recorded stress test data explains why avoidance of undesirable stops enables intelligent groups to improve transport capacities and the quality of time-dependent service qualities. These characteristics are the essential features of intelligent group controls, which minimize stops under all traffic conditions. NB 3 on page Recorded Data and the Demo page of the workbook "WTC-A-8cars-15flrs-existing" are meaningful for all workbooks.

Contract loads of 1200 KG reduce the evacuation capacity, i.e. increase evacuation times. Please refer to paragraph **"**Innovation, elevator regulations and standards", why regulations inhibit innovation.

The existing group A is a perfect traffic "simulation" system

The recorded data of this group disclose the traffic density patterns of zone A, all DDFT's, round trip times, waiting times, travel times, times to destination, average time costs per passenger for entering and leaving cars, etc. Disclosure of the recorded data of group A will prove that the calculated performance data of the EXCEL workbook for the existing and the alternative group A are conservative.

Any group with proprietary destination group controls can deliver exact data in respect of traffic density patterns and group performance data. Unfortunately, the elevator industry has a policy of silence and secrecy in respect of group performance data, although these data are essential information for the planning planning of new buildings. The elevator industry denies building planners to assess this information.

Alternative 9-car or 10-car groups A would deliver outstanding service qualities.

Workbook “WTC-A-10cars-16flrs-alternative” presents the impressive performance potential of a 10-car group with contract loads of 800 to 1000 KG serving 16 floors. This alternative would have provided group A users with outstanding time-dependent service qualities. Average waiting times would be approximately 10 seconds during traffic peaks and about 5 to 6 seconds at all other times. Data of the existing group A or traffic simulation will confirm the impressive performance potential of 10-car or 9-car groups.

Four 10-car groups would have enabled at least three additional floors for Tower WTC 4. The total of the minimum contract loads of 40 elevators could be 40’000 or 36’000 KG or even less. The total for the existing groups is 34 X 1600 = 54’400KG.

During periods with PEAK traffic densities, all cars of 10-car groups will be active. During the longer periods with medium or low traffic densities, one or more cars will not be required. This is a great bonus for intelligent buildings. Idle cars do not consume energy. The energy consumption of an intelligent 10-car group A might be approximately 50 % less in comparison with the existing group A. NB: traffic simulation also facilitates accurate calculations of energy consumption. *The availability of idle cars for special services or direct trips will be an attractive feature of intelligent buildings.*

Short waiting times imply few waiting passengers. In-line configurations probably imply that the normal width of corridors provide enough space for one or two waiting passengers. The space requirements of the alternative 10-car group will be less than the existing 8-car, particularly if we compare space requirements per floor served. The value of three or more additional floors will represent a substantial percentage of the total capital costs for elevators. <u>Exact group planning based on stress tests and traffic simulation, would have made WTC 4 a spectacularly efficient building.</u>

Existing groups B, C, and D

The 8-car group B serves three floors less than the 8-car group A. Consequently, this group has excessive simultaneous transport capacities of 7.6 %. Its time-dependent service qualities are only slightly better than group A. The configuration of group B is incomprehensible.

The 6-car group C is even worse. This group is superfluous! Group C has excessive simultaneous transport capacities of 8.2 %, but its time-dependent service qualities are worse in comparison with groups A and B. The same applies for the time-dependent service qualities of groups D and E. The 6-car configurations of groups C, D and E are absurd, because 6-car configurations imply worse time-dependent service qualities in comparison with 8-car groups A and B. *Could it be that special requirements of the first tenants of WTC 4 are responsible for these incomprehensible planning decisions*. This is unlikely, because the installed groups must satisfy all future populations of WTC 4.

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If readers wish to make stress tests for groups B, C, or D, use the RSimxx workbooks, but copy the formula in cell D4 from another WTC 4 workbook to all cells in line 4. This is essential for evaluation with realistic floor levels. Note 8 explains why the mathematical model requires calculation of floor levels based on the typical floor distance of WTC 4.

Group E

Workbook “WTC-E-6cars-11flrs-existing” calculates and demonstrates the potential of the existing group E. With carloads of 10 passengers, i.e. contract loads of 1000 KG, group E can deliver high simultaneous transport capacities up to 6.0 %. The 1600 KG contract loads of group E can deliver simultaneous transport capacities up to 6.8 %. The only contribution of these capacities is passenger comfort and a great waste of energy and building space. The time-dependent service qualities of the existing group E are the worst of all groups.

Alternative group E serving 13 floors (60 to 72)

Workbook “WTC-E-8cars-13flrs-alternative” calculates and demonstrates the potential of an alternative 8-car group E. With carloads of 9 passengers, i.e. contract loads of 900 KG, this alternative can deliver high simultaneous transport capacities up to 6.1 %. With 1600 KG contract loads, this alternative can deliver excessive simultaneous transport capacities up to 7.0 %. For an 8-car group E with 1600 KG contract loads the extreme transport capacities would be highly noticeable after completion. To demonstrate the advantages of more cars is undesirable. Instead of considering an 8-car alternative with smaller contract loads, the parties responsible for the planning of group E (and C and D) decided to reduce the number of cars to SIX and to retain the 1600 KG contract loads. TWO unforgivable errors, which cannot be justified by a logical explanation. Traffic simulation or data of existing groups could have prevented these planning faults. The planners must have been desperate that contract loads of 1600 KG did not permit sensible configurations for their FIVE-group concept for tower WTC 4. Alternatively, they were completely ignorant of the inherent relativity of group characteristics.

Alternative 10-car group E serving 14 floors (62 to 75)

Workbook “WTC-E-10cars-14flrs- alternative” calculates and demonstrates the potential of an alternative 10-car group E. With carloads of 8 passengers, i.e. contract loads of 800 KG, group E can deliver high simultaneous transport capacities up to 6.2 %.
The author does not promote or recommend smallest possible elevator cars for reasons explained in the next paragraph.

Innovation, elevator regulations and standards

Elevator regulations, standards and/or laws regulate safety- and many dimensional and technical details of elevators. Internal car dimensions, the depth of elevator pits etc. are typical examples. The procedures to adapt, change or coordinate standards are complicated and time consuming. Standards are not a dynamic system, which promotes innovation. Regulations and standards inhibit innovation.

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The present generation of high-speed elevators use mechanical speed governors to operate safety gears under the cars to prevent falling down. Huge oil buffers in pits are another standard “safety” component. These devices are the result of regulations that inhibit innovation.

Intelligent elevators control carloads, i.e. the danger of overloading applies only for down-going cars during an emergency. During normal conditions, an intelligent elevator will inform passengers that it will/may not start because of an overload. It can probably even identify the person(s), which cause the overload. In view of these facts, **intelligent groups should tolerate larger cars**, provided braking systems can control the down-speed of overloaded cars. Technically, this is a not a great problem. Elevator cars are several meters high. Braking devices on guide rails may be able to control the down speed of cars and counterweights, even if the ropes are gone. Existing safety gears must stop a falling car. Their contact area with guide rails is small.

Alternatively, elevators might have linear braking systems, i.e. a variation on linear drive systems, operated by batteries, to control the speed of a falling car and/or counterweight. Linear drive systems could power and brake cars; they might facilitate the use of lightweight ropes to replace steel wire ropes. Counterweights might balance the car weight only, or the car weight and, for example, 25 % of the contract load. Linear drive / brake systems on cars and counterweights would have to deliver the energy differential, which is not recoverable.

Building owners, architects and the entire building industry should demand performance standards for the safety of passengers in elevator cars instead of rules for mechanical safety gears, speed governors, buffers etc. Could a series of exploding airbags stop or control the speed of a falling car?

Conclusions

Elevator companies disguise the performance potential of groups by engaging in traffic simulation after empirical group planning. The simulated data are correct for groups with the imperfect configurations produced by a flawed planning process.

The practice of empirical group planning and using traffic simulation to suggest a correct planning process is false. Elevator companies and other parties mislead building owners and architects in respect of the characteristics and performance potential of groups.

These practices oblige elevator companies to maintain strict silence in respect of traffic density patterns in existing buildings and the service qualities and characteristics of existing groups. Disclosure of the recorded data of existing groups, with proprietary destination controls, reveal the true performance potential of groups, i.e. confirm that elevator companies provide false, misleading and incomplete information in respect of group performance.

These practices will stop when architects become aware that group planning is an exact task, which they can control. These developments will change the planning of future buildings, the groups of elevators in these buildings and building management systems.

Appendix chapter G: Diagram all groups WTC 4 with configuration- and performance data.

Zone Pop.	Floor Pop.	Floor nr						MAXIMA		
									Group E	WTCgrpEsim11
	125	72					11	6	Number of cars	
	125	71					10	9	Contract speed in m/s	
	125	70					9	1600	Contract load KG	
	125	69					8	1390	Zone Population	
	125	68					7	28.6	Evacuation time in minutes	
	125	67					6	6.8	Up/Down transp capacities in % pop/5 m	
	125	66					5	25.6	Average waiting times	
	125	65					4	97.2	Average travel times in the cars	
	125	64					3	122.8	Average times to destinations	
	125	63					2			
1390	140	62					1		**Group D**	WTCgrpDsim10
	140	61				9		6	Number of cars	
	140	60				8		7	Contract speed in m/s	
	140	59				7		1600	Contract load KG	
	140	58				6		1260	Zone Population	
	140	57				5		26.1	*Evacuation time in minutes*	
		56						7.9	Up/Down transp capacities in % pop/5 m	
		55						24.0	Average waiting times	
	140	54				4		92.5	Average travel times in the cars	
	140	53				3		116.5	Average times to destinations	
	140	52				2				
1260	140	51				1			**Group C**	WTCgrpCsim10
	140	50			9			6	Number of cars	
	140	49			8			6	Contract speed in m/s	
	140	48			7			1600	Contract load KG	
	140	47			6			1260	Zone Population	
	140	46			5			25.5	*Evacuation time in minutes*	
	140	45			4			8.2	Up/Down transp capacities in % pop/5 m	
	140	44			3			23.1	Average waiting times	
	140	43			2			88.2	Average travel times in the cars	
1260	140	42			1			111.4	Average times to destinations	
	140	41		12						
	140	40		11					Group B	WTCBsim13
	140	39		10				8	Number of cars	
	140	38		9				6	Contract speed in m/s	
	140	37		8				1600	Contract load KG	
	140	36		7				1680	Zone Population	
	140	35		6				21.3	*Evacuation time in minutes*	
	140	34		5				7.6	Up/Down transp capacities in % pop/5 m	
	140	33		4				17,6	Average waiting times	
	140	32		3				85.0	Average travel times in the cars	
	140	31		2				102.6	Average times to destinations	
1680	140	30		1						
	140	29	15							
	140	28	14							
	140	27	13						**Group A**	WTCgrpAsim15
	140	26	12					8	Number of cars	
	140	25	11					5	Contract speed in m/s	
	140	24	10					1600	Contract load KG	
	140	23	9					2100	Zone Population	
	140	22	8					22,6	*Evacuation time in minutes*	
	140	21	7					6.0	Up/Down transp capacities in % pop/5 m	
	140	20	6					19.2	Average waiting times	
	140	19	5					86.4	Average travel times in the cars	
	140	18	4					105.5	Average times to destinations	
	140	17	3							
	140	16	2							
2100	140	15	1							

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