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.

“Traffic” / performance calculations

Traffic calculations are the traditional method to demonstrate the UP PEAK distribution capacity of "collective selective" elevators. Unfortunately **an agreed standard method does not exist.** For this reason traffic calculations from different sources always seem to present different sets of parameters. This situation causes serious but completely unnecessary confusion because these calculations are in fact simple “muscle power” calculations. This book introduces a new calculation method and a new name: **performance calculations**.

The essence of a performance calculation is the determination of the **average Round Trip Time (RTT)** under specific UP traffic conditions. The **standard method for RTT calculation** used in this book is based on the following assumptions:

- The maximum average car load is 80 % of the contract load (load factor)
- Average weight of a passenger is 80 KG
- The last passenger leaves the car at the reversal floor level. Thereafter the car returns non-stop to floor zero
- The first stop during the UP trip is always the lowest upper floor served by the group
- All other stops are made at the reversal floor and the floors immediately below the reversal floor
- The time for entering and leaving the car is 2 seconds per passenger. This time includes the minimum dwell time per stop.
- DOWN traffic is NIL.

In this chapter we will show that calculations on this basis yield reliable RTT data for **all UP traffic densities**.

Terminology

"Probable stops": The number of stops that a car will make during the UP trip. This number depends on the **number of upper floors served** and the **number of passengers in the car**. **Appendix 1** shows a table for determination of the number of "probable stops" and the mathematical formula for its calculation.

Reversal floor level: The last UP-going passenger(s) in a car may disembark on the top floor or a floor below the top floor. The **theoretical average reversal floor level** also depends on the number of upper floors served and the number of passengers in the car. **Appendix 2** shows a table for determination of the average reversal floor level and the formula for its calculation.

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The above mentioned formulas are based on mathematical probability theory and are used throughout the elevator industry.

Dwell time: When a car makes a stop it usually has a minimum “dwell time” of one or two seconds because door closing immediately after door opening is obviously undesirable. The standard calculation method introduced by this book assumes that the minimum “dwell time” is included in the time allowance for opening and closing of the doors and the 2 seconds time allowance per passenger for entering and leaving the car. The 2 second allowance is probably too short for "collective selective" elevators during UP PEAK traffic conditions. Reason: to leave a full car can be difficult. For "intelligent elevators" conditions are better because the cars make fewer stops and the percentage of passengers leaving the car during a stop is higher. Moreover all stops are signaled during the entire trip, i.e. the next stop is known in advance. Consequently the assumptions of this paragraph imply an advantage for the calculated data of "collective selective" elevators.

Standard RTT calculation method

The standard calculation method of this book can be described in three steps.

Step 1: The basis of the average RTT is a simple addition

If we assume that the reversal level is the top floor the calculation of the average RTT is **reduced to a simple addition** of the DDFT’s of all trips made during the average round trip plus the assumed time allowance of 2 seconds per passenger for entering and leaving the car.

The “box” below shows **all DDFT’s** of an UP round trip of a car that stops at 9 upper floors (1-5-6-7-8-9-10-11-12) and then returns non-stop to floor zero. Assumed contract speed is 2.5 meters/second.

DDFT's	12		The diagram shows the round trip of a car that			
9.6 sec.	11		stops at floor 1 then continues to floor 5 and			
9.6 sec.	10		subsequently stops at floors 6 to 12.			
9.6 sec.	9		Total number of stops is 9.			
9.6 sec.	8					
9.6 sec.	7		If we assume this car does not transport			
9.6 sec.	6		passengers and doors close immediatly after			
9.6 sec.	5	DDFT	opening the RTT is the total of all DDFT's.			
	4	27.2				
	3		8 X 9.6 =	76.8	seconds	
14.4 sec.	2		trip 1 to 5	14.4	seconds	
	1		trip 12 to 0	27.2	seconds	
9.6 sec.	0		**Total DDFT's**	**118.4**	**seconds**	Ch13dia1

In case this car distributes 16 passengers into the building the **total round trip time will be 118.4 + 32 = 150.4 seconds**.

The RTT calculations of **Appendix 3** show that the RTT is not affected if stops are made on different floors.

This book uses calculated DDFT's, however; a real group will measure its own DDFT's over all possible travel distances and maintain a DDFT table. In case an elevator uses different drive characteristics and/or door times for different traffic conditions additional DDFT tables will be maintained.

Step 2: RTT adjustment for "probable stops"

The number of "probable stops" for 16 passengers going to 12 upper floors is 9.0 in accordance with the table of Appendix 1, however, this number results from rounding a figure with many digits and the true number is 9.0176++.

The number of "probable stops" is virtually always a fractional figure and for this reason **performance calculations by computers always consist of two RTT calculations**. The average RTT for "probable stops" = 9.0176 derives from linear interpolation of the RTT's for 9 and 10 stops.

RTT for 9 stops as calculated above	150.4 seconds
RTT for 10 stops calculated in the same manner	158.4 seconds
RTT for 9.02 stops	**150.6 seconds**

Step 3: RTT adjustment for average reversal floor level

The table of Appendix 2 shows that in case the car of the above example distributes 16 passengers the average reversal floor level will be 11.7 instead of 12. This implies that most of the time the car will reverse on floor 12 and sometimes on a lower floor.

To calculate the adjusted average RTT we assume that the "stop-floors" of the sample calculation, i.e. floors 5 to 12 are located 0.3 floors lower (=1.2 meter) as they really are. The DDFT for the **distance floor 1 to floor 5** must be recalculated for 16 – 1.2 = 14.8 meters. For contract speed 2.5 m/s the time saving is 1.2 meter divided by 2.5 m/s = 0.5 seconds. The non-stop return trip from the average reversal floor level to floor zero is reduced by 0.5 seconds as well. The **adjusted average RTT** is **150.6 seconds less 1 second = <u>149.6 seconds</u>**.

This calculation method is the basis of the calculated data structures and Comparative Performance Tables presented in this book.

Calculation of the other parameters

The average RTT of 149.6 seconds and the DDFT data enables calculation of all performance parameters as follows:

Number of round trips each car can make In 5 minutes = 300 / RTT (149.6) =	2.01 round trips
Number of passengers distributed by the group Per 5 minutes = 2.01 X 16 X 4 =	128.3 passengers
DC5 in % of population (900 persons) = 128.3 / 9 =	14.3 %
Theoretical minimum Departure INTERVAL (RTT divided by the number of cars) 149.6 / 4 =	37.4 seconds

Theoretical minimum Average Waiting Time (AWT) is the
Theor. min. Dep. INTERVAL divided by 2 = 37.4 / 2 = 18.7 seconds

The travel time in the car begins when the doors start closing on floor zero. The **Average Travel Time in the Car (ATTC)** for the UP trip is calculated as follows:

- **The ATTC is longest + shortest travel time in the car divided by TWO.**
- The **longest possible travel time in the car** applies for the person who **is last out on the reversal floor**. This is the RTT reduced by the car loading time at floor zero and the return trip to floor zero.
- The **shortest possible travel time in the car** applies for the person **who is first out on floor ONE.**

Longest travel time 149.6 - 16 (car loading) – 26.7 (return trip, 27.2-0.5) =	106.9 seconds
Shortest travel time (DDFT floor zero to ONE)	9.6 seconds
ATTC = (106.9 + 9.6) / 2 =	58.3 seconds

Please note that the car loading time at floor zero is included in the average RTT and consequently in the theoretical minimum Departure INTERVAL and the theoretical minimum AWT.

The **Theoretical minimum Average Time To Destination (ATTD)**
is the AWT + ATTC = ATTD = 18.7 + 58.3 = 77.0 seconds

“Manual” RTT calculations with rounded data for DDFT’s, "probable stops" and reversal floor levels from the tables in Appendices 1, 2 and 5 will be quite accurate. The computer generated data of CPT’s may be slightly different because they are based on exact data.

Average Travel Time in the Car (ATTC) and Average Time To Destination (ATTD)

This book introduces these new parameters because they **are more informative and reliable** than the misleading AWT of traditional traffic calculations (Chapter 6). **ATTC's, like RTT’s, are reliable parameters** because they are **based on DDFT’s**.

ATTD’s are of a slightly lower quality because they include theoretical minimum AWT’s.

In this connection please note that the calculated AWT’s of "intelligent elevators" will be much more reliable than the calculated AWT’s of "collective selective" elevators because "Intelligent elevators" will permanently monitor and control the Departure INTERVALS on the basis RTT target data for prevailing traffic conditions. For this reason the calculated **parameters for groups of "intelligent elevators"** are of a **better quality,** i.e. more realistic**,** than the calculated parameters of "collective selective" groups.

Chapter 13: Transparent performance calculations

Transparent, simple and checkable

DDFT's are binding data that are easy to check. They **cannot be manipulated**. Please note that the **group control system does not play a role in RTT calculations** for traditional elevators. The average RTT's calculated and used in this book depend entirely on the DDFT's, car loads, "probable stops" and reversal floor levels. Consequently **performance calculations on the basis of DDFT's** are transparent, simple and checkable.

Intelligent destination elevators use "brain power" to make the best possible use their "muscle power". This objective is achieved by the intelligent assignment of passengers to specific cars for best-possible car operations.

The remaining chapters of this book describe in detail how groups with intelligent destination controls can use different modes of car operations to achieve best-possible service qualities. Customer preferences in respect of combinations of service qualities can influence the selection of the mode of car operation for specific traffic conditions.

To "fine tune" the consistency of time dependent service qualities "intelligent elevators" will be able to adjust at any time the rates of acceleration, deceleration and jerk and/or the door times as may be required to enhance the positioning of cars.

The efficiency of UP traffic

This is the **essential efficiency problem** of a group of elevators because passengers on floor zero may have **any upper floor** as their destination. In Chapter 16: "Module for heavy simultaneous UP and DOWN traffic" readers will see how on the basis of efficient UP traffic simultaneous UP and DOWN traffic can be optimized as well.

Performance calculations are reversible

If we assume that the non-stop return trip used in RTT calculations for UP traffic is a non-stop UP trip and the "probable stops" are made during the DOWN trip we will note that CPT's can provide valuable data for maximum DOWN transport capacities (TC5's) as well. For "intelligent elevators" the **DC5 maxima equal their TC5 maxima.** (TC5 is the DOWN transport capacity per 5 minutes)

The DC5 maxima of "intelligent elevators" also give us information about the **TC5 maxima of "collective selective" groups.** During DOWN PEAK traffic their full cars may cause "collective selective" elevators to make few stops, i.e. to operate in a similar manner as intelligent destination elevators during the UP trip.

Performance calculations for High Rise elevators

The standard calculation method presented in this chapter provides reliable and conservative RTT data for low speed Low Rise elevators. This is true for high speed High Rise elevators as well. In **Appendix 4** the 12 floors served in the Low Rise sample calculation are moved upwards to floors 31 to 42. The travel distance to the top floor is 168 meter and the contract speed is assumed to be 6 meter/second.

The three alternative round trips with 9 stops show that the standard calculation method returns a conservative average RTT of 152.5 seconds. **Please note that the accuracy of the calculation is not all that important. It is important to use a standard method that makes results comparable.**

RTT calculations that include DOWN traffic

For groups with a contract speed of 2.5 m/s the calculation of the revised RTT when a car makes additional stops during the DOWN trip is easy. Each DOWN stop increases the total of all DDFT's by 8 seconds. Each DOWN going passenger increases the RTT by two seconds.

For high contract speeds the time-cost for making an additional stop during an UP or DOWN trip depends on the position of the floor served, i.e. the maximum speed that can be reached between floors.

Appendix 5 shows for a DOWN trip how the **minimal-, the maximal- and the average time-cost for additional stops** can be calculated. The purpose of Appendix 5 is to show how and why the time cost for additional stops is affected by the contract speed.

"Intelligent destination" group controls will not require these calculation methods because they learn these time costs from the analysis of car operations.

DDFT Tables

Appendix 6 shows a table with the DDFT's for floor distances up to 100 meters and contract speeds from 2.5 m/s to 10 m/s. Each "Intelligent destination" group control will have a DDFT table similar to Appendix 6 that is based on the contract speed and the other characteristics of a specific group. This type of table is a standard element of the calculated data structures that is a basic element of the artificial intelligence of groups with intelligent destination controls.

An "intelligent destination" group control may use several tables of this type with alternative DDFT's on the basis of different rates for acceleration, deceleration, jerk and/or door times.

Appendices:

Appendix 1: Table and formula for determination of "probable stops" or "probable destinations"
Appendix 2: Table and formula for determination of the average reversal level
Appendix 3: Three RTT calculations showing that the positions of the floors on which stops are made do not affect the RTT of Low Rise elevators.
Appendix 4: Three RTT calculations showing that the standard calculation method of this chapter yields a reliable and conservative RTT for High Rise elevators as well.

Appendix 5: Average time-cost per stop for elevators with high contract speeds.
Appendix 6: Table stating DDFT's for floor distances up to 100 meters and contract speeds from 2.5 m/s to 10 m/s.

Appendix 1

Table for the determination of "probable stops" or "probable destinations"

Number of upper floors served			Number of passengers in the car																	Ch13dia2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	1	1.5	1.75	1.88	1.94	1.97	1.98	1.99	2	2	2	2	2	2	2	2	2	2	2	2
3	1	1.67	2.11	2.41	2.61	2.74	2.82	2.88	2.92	2.95	2.97	2.98	2.99	2.99	2.99	3	3	3	3	3
4	1	1.75	2.31	2.73	3.05	3.29	3.47	3.6	3.7	3.78	3.83	3.87	3.91	3.93	3.95	3.96	3.97	3.98	3.98	3.99
5	1	1.8	2.44	2.95	3.36	3.69	3.95	4.16	4.33	4.46	4.57	4.66	4.73	4.78	4.82	4.86	4.89	4.91	4.93	4.94
6	1	1.83	2.53	3.11	3.59	3.99	4.33	4.61	4.84	5.03	5.19	5.33	5.44	5.53	5.61	5.68	5.73	5.78	5.81	5.84
7	1	1.86	2.59	3.22	3.76	4.22	4.62	4.96	5.25	5.5	5.72	5.9	6.06	6.19	6.31	6.41	6.49	6.56	6.63	6.68
8	1	1.88	2.64	3.31	3.9	4.41	4.86	5.25	5.6	5.9	6.16	6.39	6.59	6.77	6.92	7.06	7.17	7.28	7.37	7.45
9	1	1.89	2.68	3.38	4.01	4.56	5.05	5.49	5.88	6.23	6.54	6.81	7.05	7.27	7.46	7.63	7.79	7.92	8.04	8.15
10	1	1.9	2.71	3.44	4.1	4.69	5.22	5.7	6.13	6.51	6.86	7.18	7.46	7.71	7.94	8.15	8.33	8.5	8.65	8.78
11	1	1.91	2.74	3.49	4.17	4.79	5.36	5.87	6.34	6.76	7.15	7.5	7.81	8.1	8.37	8.61	8.82	9.02	9.2	9.37
12	1	1.92	2.76	3.53	4.23	4.88	5.47	6.02	6.52	6.97	7.39	7.78	8.13	8.45	8.75	9.02	9.27	9.49	9.7	9.89
13	1	1.92	2.78	3.56	4.29	4.96	5.58	6.15	6.68	7.16	7.61	8.03	8.41	8.76	9.09	9.39	9.67	9.92	10.2	10.4
14	1	1.93	2.79	3.59	4.34	5.03	5.67	6.26	6.81	7.33	7.8	8.25	8.66	9.04	9.39	9.72	10	10.3	10.6	10.8
15	1	1.93	2.8	3.62	4.38	5.09	5.75	6.36	6.94	7.48	7.98	8.45	8.88	9.29	9.67	10	10.4	10.7	11	11.2
16	1	1.94	2.82	3.64	4.41	5.14	5.82	6.45	7.05	7.61	8.13	8.63	9.09	9.52	9.92	10.3	10.7	11	11.3	11.6
17	1	1.94	2.83	3.66	4.45	5.18	5.88	6.53	7.15	7.73	8.27	8.79	9.27	9.73	10.2	10.6	10.9	11.3	11.6	11.9
18	1	1.94	2.84	3.68	4.47	5.23	5.94	6.61	7.24	7.84	8.4	8.94	9.44	9.91	10.4	10.8	11.2	11.6	11.9	12.3
19	1	1.95	2.85	3.7	4.5	5.26	5.99	6.67	7.32	7.94	8.52	9.07	9.59	10.1	10.6	11	11.4	11.8	12.2	12.6
20	1	1.95	2.85	3.71	4.52	5.3	6.03	6.73	7.4	8.03	8.62	9.19	9.73	10.2	10.7	11.2	11.6	12.1	12.5	12.8

Formula for calculating the number of "probable stops":

PS = NUF x (1 – ((NUF – 1) / NUF) ^ PIC)

PS = Number of "probable stops or destinations"
NUF = Number of upper floors served
PIC = Number of passengers in the car (car load)

NB: The data in the above table are calculated with LOTUS123. When the above table is produced with EXCEL most data are identical, however, some data are slightly different.

Chapter 13: Transparent performance calculations

Appendix 2

Table for determination of the average reversal level.

Number of upper floors served			Number of passengers in the car																Ch13dia3	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	1.50	1.75	1.88	1.94	1.97	1.98	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.44	2.67	2.79	2.86	2.91	2.94	2.96	2.97	2.98	2.99	2.99	2.99	3.00	3.00	3.00	3.00	3.00	3.00	3.00
4	2.50	3.13	3.44	3.62	3.73	3.81	3.86	3.90	3.92	3.94	3.96	3.97	3.98	3.98	3.99	3.99	3.99	3.99	4.00	4.00
5	3.00	3.80	4.20	4.43	4.58	4.69	4.76	4.81	4.86	4.89	4.91	4.93	4.94	4.96	4.96	4.97	4.98	4.98	4.99	4.99
6	3.50	4.47	4.96	5.24	5.43	5.56	5.65	5.72	5.78	5.82	5.85	5.88	5.90	5.92	5.93	5.94	5.95	5.96	5.97	5.97
7	4.00	5.14	5.71	6.05	6.27	6.43	6.54	6.63	6.69	6.75	6.79	6.82	6.85	6.88	6.89	6.91	6.92	6.94	6.94	6.95
8	4.50	5.81	6.47	6.86	7.11	7.29	7.43	7.53	7.61	7.67	7.72	7.76	7.80	7.83	7.85	7.87	7.89	7.90	7.92	7.93
9	5.00	6.48	7.22	7.66	7.95	8.16	8.31	8.43	8.52	8.59	8.65	8.70	8.74	8.77	8.80	8.83	8.85	8.87	8.88	8.90
10	5.60	7.14	7.98	8.47	8.79	9.02	9.19	9.32	9.43	9.51	9.58	9.63	9.68	9.72	9.75	9.78	9.81	9.83	9.85	9.87
11	6.00	7.82	8.73	9.27	9.63	9.88	10.07	10.22	10.33	10.42	10.50	10.56	10.62	10.66	10.70	10.74	10.76	10.79	10.81	10.83
12	6.50	8.49	9.48	10.07	10.47	10.74	10.95	11.11	11.24	11.34	11.42	11.49	11.55	11.60	11.65	11.69	11.72	11.75	11.77	11.79
13	7.00	9.15	10.23	10.87	11.30	11.60	11.83	12.00	12.14	12.25	12.35	12.42	12.49	12.54	12.59	12.63	12.67	12.70	12.73	12.76
14	7.50	9.82	10.98	11.68	12.14	12.46	12.71	12.90	13.05	13.17	13.27	13.35	13.42	13.48	13.54	13.58	13.62	13.66	13.69	13.72
15	8.13	10.21	11.73	12.46	12.97	13.32	13.59	13.79	13.95	14.08	14.19	14.28	14.36	14.42	14.48	14.53	14.57	14.61	14.65	14.68
16	8.50	11.16	12.48	13.28	13.81	14.18	14.46	14.68	14.85	14.99	15.11	15.21	15.29	15.36	15.42	15.48	15.52	15.57	15.60	15.64
17	9.00	11.82	13.24	14.08	14.64	15.04	15.34	15.57	15.76	15.91	16.03	16.13	16.22	16.30	16.36	16.42	16.47	16.52	16.56	16.59
18	9.50	12.49	13.99	14.88	15.48	15.90	16.22	16.46	16.66	16.82	16.95	17.06	17.15	17.24	17.31	17.37	17.42	17.47	17.51	17.55
19	10.00	13.16	14.74	15.68	16.31	16.76	17.09	17.35	17.56	17.73	17.87	17.99	18.09	18.17	18.25	18.31	18.37	18.42	18.47	18.51
20	10.50	13.83	15.49	16.48	17.15	17.62	17.97	18.24	18.46	18.64	18.79	18.91	19.02	19.11	19.19	19.26	19.32	19.37	19.42	19.47

Formula for determination of the average reversal floor level.

RL = NUF – ((NUF-1)^PIC + (NUF-2)^PIC + ...((NUF-(NUF-1))^PIC) / NUF^PIC

RL = Average Reversal Level
NUF = Number of upper floors served
PIC = Number of passengers in the car (car load)

Appendix 3:

The three calculations below show that the floors on which stops are made does not affect the RTT of Low Rise elevators.

RTT calculations for a "collective selective" elevator making 9 "probable stops"

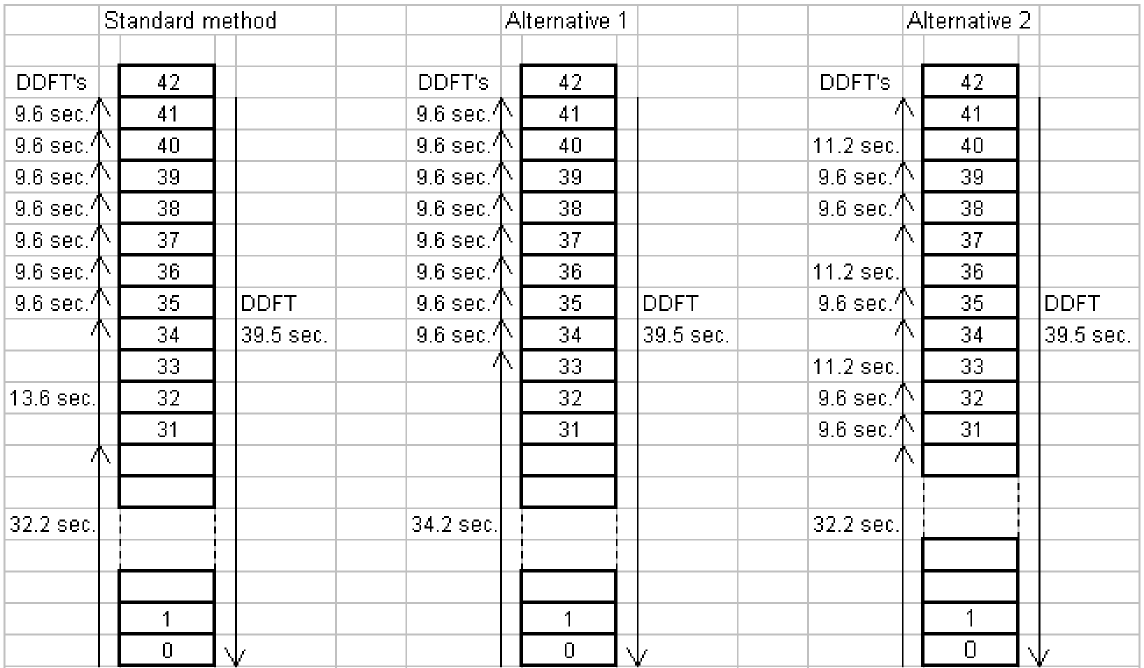
DDFT's	Floor		DDFT's	Floor		DDFT's	Floor	
	12			12			12	
9.6 sec.	11		9.6 sec.	11			11	
9.6 sec.	10		9.6 sec.	10		11.2 sec.	10	
9.6 sec.	9		9.6 sec.	9		9.6 sec.	9	
9.6 sec.	8		9.6 sec.	8		9.6 sec.	8	
9.6 sec.	7		9.6 sec.	7			7	
9.6 sec.	6		9.6 sec.	6		11.2 sec.	6	
9.6 sec.	5	DDFT	9.6 sec.	5	DDFT	9.6 sec.	5	DDFT
	4	27.2	9.6 sec.	4	27.2		4	27.2
	3			3		11.2 sec.	3	
14.4 sec.	2		14.4 sec.	2		9.6 sec.	2	
	1			1		9.6 sec.	1	
9.6 sec.	0			0		9.6 sec.	0	

Total all DDFT's			**Total all DDFT's**			**Total all DDFT's**		
8 X 9.6 =	76.8		8 X 9.6 =	76.8		6 X 9.6 =	57.6	
trip 1 to 5	14.4		trip 0 to 4	14.4		3 X 11.2	33.6	
trip 12 to 0	27.2		trip 12 to 0	27.2		trip 12 to 0	27.2	
Total DDFT's	**118.4**	**sec.**	Total DDFT's	**118.4**	**sec.**	Total DDFT's	**118.4**	**sec.**
"Time cost" passengers IN /OUT			**"Time cost" passengers IN /OUT**			**"Time cost" passengers IN /OUT**		
16 X 2 =	32		16 X 2 =	32		16 X 2 =	32	
RTT	**150.4**	**sec.**	**RTT**	**150.4**	**sec.**	**RTT**	**150.4**	**sec.**
								Ch13dia4

Appendix 4

The RTT calculations below show that the standard calculation method of this chapter yields a reliable and conservative Round Trip Time (RTT).

The calculations below are based on a contract speed of 6 meter/second.



Total all DDFT's		
7 X 9.6 =	67.2	
trip 31 to 35	13.6	(16 m.)
Trip 0 to 31	32.2	(124 m.)
trip 42 to 0	39.5	(168 m.)
Total DDFT	**152.5**	**sec.**
"Time cost" passengers IN /OUT		
16 X 2 =	32	
RTT	**184.5**	**sec.**

Total all DDFT's		
8 X 9.6 =	76.8	
trip 0 to 34	34.2	(135 m.)
trip 42 to 0	39.5	(168 m.)
Total DDFT	**150.5**	**sec.**
"Time cost" passengers IN /OUT		
16 X 2 =	32	
RTT	**182.5**	**sec.**

Total all DDFT's		
5 X 9.6 =	48.0	
3 X 11.2	33.6	
Trip 0 to 31	32.2	(124 m.)
trip 42 to 0	39.5	(168 m.)
Total DDFT	**153.3**	**sec.**
"Time cost" passengers IN /OUT		
16 X 2 =	32	
RTT	**185.3**	**sec.**

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Appendix 5

Average time-cost per stop for elevators with high contract speeds.

The High Rise group serving floors 31 to 42 in Appendix 4 with a contract speed of 6 m/sec has a total travel distance of 168 meters. The distance from floor zero to floor 31 is 124 meters end the distance 31 to 42 is 44 meters.

When the car starts a DOWN trip on floor 42 the time cost for making ONE additional stop will be minimal in case the stop is made on floor 41 because the car does not reach a high speed over the floor distance of 4 meter. In case the ONE additional stop is made on floor 31 the car must decelerate from contract speed and consequently in this case the time-cost will be more.

The average time cost for ONE additional stop on floor 41 is calculated as follows:

DDFT 4 meters	9.6 seconds
DDFT 164 meters	38.8 seconds
Total	48.4 seconds,

Minimum time cost: 48.4 minus DDFT 168 meters = 39.5 = **8.9 seconds**.

In case the ONE additional stop is made on floor 31 the calculation is as follows:

DDFT 44 meters	18.8 seconds
DDFT 124 meters	32.2 seconds
Total	51.00 seconds

Maximum time cost: 51.0 minus DDFT 168 meters = 39.5 = **11.5 seconds**.
The **average** of the minimum and the maximum **time-cost is 10.2 seconds.**

In case **THREE** additional stops are made during the DOWN trip the maximal average time cost will occur if the total travel distance of 44 meters is divided in two distances of 16 meter and one distance of 12 meter. The minimal average time cost will occur if stops are made on floors 41, 40 and 39 and the car travels non-stop from floor 39 to floor zero thereafter.

DDFT 16 meters	13.6 seconds, total for TWO distances 27.2 seconds
DDFT 12 meters	12.5 seconds
DDFT 124 meters	32.2 seconds
Total	71.9 seconds
DDFT 168 meters	39.5 seconds
Difference	32.4 seconds, i.e. 10.8 seconds per stop.

DDFT 4 meters	9.6 seconds, total for THREE distances 28.6 seconds
DDFT 156 meters	37.5 seconds
Total	66.1 seconds
DDFT 168 meters	39.5 seconds
Difference	33.7 seconds, i.e. 11.2 seconds per stop.

The **average** of the minimum and the maximum **time-cost is 11.0 seconds** in this case.

The purpose of above calculations is to show **why** the average “time cost” per stop of high speed elevators varies. "Intelligent elevators" will learn these averages from analysis of car operations, as described in Chapter 17 pages 2 and 3.

Appendix 6

DDFT's for various speeds and floor distances up to 100 meter

Floor distance in meters	2.5 m/sec	3.0 m/sec	3.15 m/sec	4.0 m/sec	5.0 m/sec	6.0 m/sec	7.0 m/sec	8.0 m/sec	10.0 m/sec
4	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
5	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
6	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
8	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
10	12.0	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
12	12.8	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
14	13.6	13.2	13.1	13.1	13.1	13.1	13.1	13.1	13.1
16	14.4	13.8	13.7	13.6	13.6	13.6	13.6	13.6	13.6
18	15.2	14.5	14.4	14.0	14.0	14.0	14.0	14.0	14.0
20	16.0	15.2	15.0	14.5	14.5	14.5	14.5	14.5	14.5
22	16.8	15.8	15.6	15.0	14.9	14.9	14.9	14.9	14.9
24	17.6	16.5	16.3	15.5	15.3	15.3	15.3	15.3	15.3
26	18.4	17.2	16.9	16.0	15.7	15.7	15.7	15.7	15.7
28	19.2	17.8	17.5	16.5	16.1	16.1	16.1	16.1	16.1
30	20.0	18.5	18.2	17.0	16.5	16.5	16.5	16.5	16.5
32	20.8	19.2	18.8	17.5	16.9	16.9	16.9	16.9	16.9
34	21.6	19.8	19.4	18.0	17.3	17.2	17.2	17.2	17.2
36	22.4	20.5	20.1	18.5	17.7	17.5	17.5	17.5	17.5
38	23.2	21.2	20.7	19.0	18.1	17.9	17.9	17.9	17.9
40	24.0	21.8	21.3	19.5	18.5	18.2	18.2	18.2	18.2
42	24.8	22.5	22.0	20.0	18.9	18.5	18.5	18.5	18.5
44	25.6	23.2	22.6	20.5	19.3	18.8	18.8	18.8	18.8
46	26.4	23.8	23.3	21.0	19.7	19.2	19.1	19.1	19.1
48	27.2	24.5	23.9	21.5	20.1	19.5	19.4	19.4	19.4
50	28.0	25.2	24.5	22.0	20.5	19.8	19.7	19.7	19.7
52	28.8	25.8	25.2	22.5	20.9	20.2	20.0	20.0	20.0
54	29.6	26.5	25.8	23.0	21.3	20.5	20.2	20.2	20.2
56	30.4	27.2	26.4	23.5	21.7	20.8	20.5	20.5	20.5
58	31.2	27.8	27.1	24.0	22.1	21.2	20.8	20.8	20.8
60	32.0	28.5	27.7	24.5	22.5	21.5	21.1	21.0	21.0
62	32.8	29.2	28.3	25.0	22.9	21.8	21.4	21.3	21.3
64	33.6	29.8	29.0	25.5	23.3	22.2	21.6	21.5	21.5
66	34.4	30.5	29.6	26.0	23.7	22.5	21.9	21.8	21.8
68	35.2	31.2	30.2	26.5	24.1	22.8	22.2	22.0	22.0
70	36.0	31.8	30.9	27.0	24.5	23.2	22.5	22.3	22.3
72	36.8	32.5	31.5	27.5	24.9	23.5	22.8	22.5	22.5
74	37.6	33.2	32.1	28.0	25.3	23.8	23.1	22.8	22.8
76	38.4	33.8	32.8	28.5	25.7	24.2	23.4	23.0	23.0
78	39.2	34.5	33.4	29.0	26.1	24.5	23.6	23.3	23.2
80	40.0	35.2	34.0	29.5	26.5	24.8	23.9	23.5	23.4
82	40.8	35.8	34.7	30.0	26.9	25.2	24.2	23.8	23.6
84	41.6	36.5	35.3	30.5	27.3	25.5	24.5	24.0	23.9
86	42.4	37.2	36.0	31.0	27.7	25.8	24.8	24.3	24.1
88	43.2	37.8	36.6	31.5	28.1	26.2	25.1	24.5	24.3
90	44.0	38.5	37.2	32.0	28.5	26.5	25.4	24.8	24.5
92	44.8	39.2	37.9	32.5	28.9	26.8	25.6	25.0	24.7
94	45.6	39.8	38.5	33.0	29.3	27.2	25.9	25.3	24.9
96	46.4	40.5	39.1	33.5	29.7	27.5	26.2	25.5	25.1
98	47.2	41.2	39.8	34.0	30.1	27.8	26.5	25.8	25.3
100	48.0	41.8	40.4	34.5	30.5	28.2	26.8	26.0	25.5

Characteristics of elevators			Remarks		See NB
Speed	>	see table	18.5	means car reaches contract speed	
Acceleration and deceleration rates	1	m/s^2			
Jerk rate	1	m/s^3	13.6	means DDFT improves in comparison with the next lower contract speed.	
Door closing time	2.5	seconds			
Door opening time	2	seconds			
Time gain advanced door opening	0	seconds			Ch13dia6

NB A car with a contract speed of 10 meters/second requires a travel distance of 110 meters to momentarily reach the contract s
Please refer to the Appendix of Chapter 3 for additional data.