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 chapter presents the module for moderate traffic conditions in a matrix format. Three-dimensional calculated- and operational data structures will be attractive when intelligent destination controls are realized.

Moderate traffic conditions

This term describes traffic conditions that do not require high transportation capacities, i.e. the use of direct-trip patterns is not required. During these conditions group "brain power" can concentrate exclusively on achieving best-possible passenger comfort.

Traffic conditions in tall buildings are at most times moderate.

Best-possible passenger comfort

Can be defined as follows:

- The time-dependent service qualities should as short and as consistent as possible.
- The average number of passengers in the cars should be as low as possible

These service qualities, together with ride comfort and air-conditioning or ventilation of the cars, define best-possible passenger comfort.

Best-possible INTERVAL (time-space) between cars

The best-possible INTERVAL is the shortest consistent INTERVAL that is possible for prevailing or anticipated traffic conditions. The best-possible INTERVAL requires shortest possible consistent RTT's. This requirement also maximizes transport capacities and minimizes the average numbers of passengers in the cars. All time-dependent service qualities AWT, ATTC and ATTD depend directly on consistent and shortest possible RTT's. Conclusion: **Best-possible INTERVALS assure best-possible time-dependent service qualities and comfort**.

The above logic also explains why the prime objective of intelligent destination controls during all traffic conditions is the **minimizing and equalizing RTT's**. During periods of heavy traffic RTT's must be further reduced to increase transport capacities. Consequently AWT's and their bandwidth increase but ATTC's and ATTD's are reduced (see chapter 15 and CPT's in other chapters).

Module for moderate traffic conditions

To achieve best-possible intervals the **ability to set the numbers of permitted UP and DOWN stops for momentary or anticipated traffic conditions** is essential.

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The artificial experience system of intelligent groups facilitates to recognition and prediction of traffic conditions in terms of traffic densities and other data. These controls will set permitted number of stops and performance targets that will satisfy traffic conditions in accordance with customer preferences.

The **module for moderate traffic conditions** can be a **matrix** that states the RTT and all performance data for all possible numbers of stops and passengers for service to all floors.

The table below shows a part of this matrix for a group of intelligent destination elevators with a **contract speed of 2.5 m/s serving 13 upper floors**. All floor distances are 4 meters.

Round Trip Time (RTT) matrix for round trips over full building height. Floors served: 13.

Number	Sum of		Total of all passengers transported during round trip														
of add.	all															Ch17dia1	
stops	DDFT's	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	57.6	59.6	61.6	63.6	65.6	67.6	69.6	71.6	73.6	75.6	77.6	79.6	81.6	83.6	85.6	87.6	89.6
1	65.6	67.6	69.6	71.6	73.6	75.6	77.6	79.6	81.6	83.6	85.6	87.6	89.6	91.6	93.6	95.6	97.6
2	73.6	75.6	77.6	79.6	81.6	83.6	85.6	87.6	89.6	91.6	93.6	95.6	97.6	99.6	101.6	103.6	105.6
3	81.6	83.6	85.6	87.6	89.6	91.6	93.6	95.6	97.6	99.6	101.6	103.6	105.6	107.6	109.6	111.6	113.6
4	89.6	91.6	93.6	95.6	97.6	99.6	101.6	103.6	105.6	107.6	109.6	111.6	113.6	115.6	117.6	119.6	121.6
5	97.6	99.6	101.6	103.6	105.6	107.6	109.6	111.6	113.6	115.6	117.6	119.6	121.6	123.6	125.6	127.6	129.6
6	105.6	107.6	109.6	111.6	113.6	115.6	117.6	119.6	121.6	123.6	125.6	127.6	129.6	131.6	133.6	135.6	137.6
7	113.6	115.6	117.6	119.6	121.6	123.6	125.6	127.6	129.6	131.6	133.6	135.6	137.6	139.6	141.6	143.6	145.6
8	121.6	123.6	125.6	127.6	129.6	131.6	133.6	135.6	137.6	139.6	141.6	143.6	145.6	147.6	149.6	151.6	153.6
9	129.6	131.6	133.6	135.6	137.6	139.6	141.6	143.6	145.6	147.6	149.6	151.6	153.6	155.6	157.6	159.6	161.6
10	137.6	139.6	141.6	143.6	145.6	147.6	149.6	151.6	153.6	155.6	157.6	159.6	161.6	163.6	165.6	167.6	169.6
11	145.6	147.6	149.6	151.6	153.6	155.6	157.6	159.6	161.6	163.6	165.6	167.6	169.6	171.6	173.6	175.6	177.6
12	153.6	155.6	157.6	159.6	161.6	163.6	165.6	167.6	169.6	171.6	173.6	175.6	177.6	179.6	181.6	183.6	185.6
	57.6	seconds is the total of the DDFT's of non-stop trips from floor zero to floor 13 and back to floor zero.															

The 57.6 seconds in the top left corner of the matrix is the sum of the DDFT's of a non-stop UP trip from floor zero to floor 13 (DDFT 28.6 seconds) and a non-stop return trip to floor zero immediately afterwards.

During a round trip each and every additional stop increases the total of the DDFT's by 8 seconds. Whether a stop happens during the UP or the DOWN trip does not affect the total of the DDFT's. Each passenger transported during the round trip increases the RTT by 2 seconds for boarding and leaving the car.

The matrix can be extended to 24 stops and 32 passengers, i.e. the maxima for each round trip. The above **section** of the matrix provides the RTT data for light to medium traffic densities.

The 3-Dimensional calculated data structure

The above matrix can be the basis of a 3-D calculated data structure. Please imagine an additional layer of data below the RTT's that states the TTC5 (total of DC5 plus TC5) for the total number of passengers and the total number of additional stops for each RTT above. Each TTC5 points to the matrix layers and sections below that provide numbers for permitted numbers of UP and DOWN stops and other data that will deliver the specific combination of the momentary or anticipated UP and DOWN traffic densities, i.e. the required DC5 and TC5.

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The calculated data structure will enable intelligent destination controls to assess the extended data tables that were outlined in the previous chapter. This implies the control has the data/know-how to decide the modes of car operations that will be able to satisfy any combination of anticipated traffic densities.

For writing this book the Two-dimensional **data table approach** was a practical method to show the relativity of performance parameters and how these data can be used for logical control decisions. In a real control the **3-D matrix format** will be the more attractive format for calculated data structures.

Calculated data structures can also disclose performance data for round trips with lower reversal floor levels.

The Operational data structure

The operational data structure or memory of a group will be identical or very similar to the format of the calculated data structure. However, this second data structure is based on data that result from monitoring, recording and analyzing car operations. The TWO data structures enable checking the data of each other. If the calculated data are consistently different from recorded data the assumptions for the calculated data must be incorrect, i.e. the calculated data structure needs correction. Discrepancies between calculated data and recorded data may be an indication of passengers or technical problems causing longer RTT's or other problems. These roundtrips can be ignored for statistical analysis.

Average time-cost for each additional stop

Intelligent destination group controls can determine the average of time cost for acceleration, deceleration and door operation per additional stop by analysis of operations as follows: From the RTT of a round trip the total of all dwell times that occurred during the round trip is deducted. The DDFT's of the non-stop trips from floor zero to the reversal floor and back to floor zero are deducted as well. The remaining time represents the total of the time-costs for acceleration, deceleration and door operation that was required for making additional stops during a round trip. Division of this total time-cost by the number of stops delivers accurate data of the average time cost for additional stops. This calculation can be done separately for UP and DOWN trips as well. For high rise groups this method can be applied for the UP and DOWN trips above the lowest floor served. This way accurate data for time costs for acceleration and deceleration of high-rise high-speed groups per additional stop can be obtained and how these time costs are affected by the number of additional stops.

The calculation method used in Appendix 5 of chapter 13 shows the reasons why time costs per additional stop average increases for elevators with high contract speeds. For a real group this calculation method is irrelevant. **A real group will learn** these data as described above. The calculated- and operational data structures of real groups will both use data learned from car operations. Intelligent destination group controls have TWO data structures to review instantaneously the modes of car operations that will satisfy prevailing- or anticipated traffic conditions. This enables the control to set the numbers for permitted stops and relevant performance targets.

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Optimizing the Departure INTERVAL

As already mentioned in Chapter 6 under the heading Waiting Time Bandwidth (WTB): **Intelligent elevators will avoid waiting times that are shorter than the best-possible or target AWT for prevailing traffic conditions**.

This means that if an approaching car would cause a short waiting time for a specific service call and the NEXT car would cause a better or preferable differential with the **target waiting time** the service call will be assigned to a NEXT car.
This practice has several advantages. Passengers waiting on other floors that are assigned to the first car will be served earlier. The waiting passenger on the by-passed floor may be joined by another passenger during the longer waiting time and a NEXT car may collect two passengers with one stop.

This principle may be affected by other conditions, for example, a car must make a stop on that floor anyway to disembark a passenger or if a passenger in the first car and the passenger making the service call have a coincident destination. However, **each time <u>a stop is avoided</u> the average waiting time** and the efficiency of the group improves **because the average RTT is reduced.** All service qualities improve.

The Waiting Time Bandwidth of Chapter 6 confirms that the **<u>quality of a WTB</u> is defined by the relationship between the numbers of short and long waiting times.**

During moderate traffic conditions the cars make relatively few stops and the opportunities for optimizing RTT's and INTERVALS by controlling the number of permitted stops will be good.

An intelligent group control will **continuously monitor the INTERVALS between individual cars <u>and</u> the waiting times that will result when a service call from a <u>specific floor</u> is assigned to a specific car**. These data are continuously re-calculated for consultation when a service call occurs.

Likewise the target RTT and car load of each car and all group service qualities will be continuously re-calculated for consultation when a service call occurs. At the moment a service / destination call is entered these momentary data will support the group's ability to make the best possible assignment immediately.

Car operations for best-possible time-dependent service qualities

Although the targets for RTT and INTERVAL of the examples in this chapter are based on round trips to the top- or reversal floor the artificial intelligence system may decide that it is advantageous to reverse the direction of a car at any time. Obviously such reversal should happen only after passengers in the reversing car have been delivered to their destinations and no passengers on higher or lower floors have been assigned to the reversing car. During periods of heavy traffic reversals are unlikely, however, during light or medium traffic this flexibility may enable to improve the position of the car in the "string" of cars to improve time-dependent service qualities.

The availability of momentary data described above will support this type of decisions.

Intelligent elevators will have several other possibilities to optimize the INTERVALS. Adjustment of the car speed and/or dwell times and/or door open and closing times can all be used to optimize the INTERVAL between individual cars. During the development of Intelligent destination group controls software refinements that enable the optimizing of INTERVALS must receive special attention.

Comparison of 4- and 6-car groups

The RTT matrices also enable comparison of the theoretically possible service qualities of 4-car and 6-car collective selective groups. Chapter 6 showed that a 4-car group serving 12 floors has a better UP PEAK performance than a 6-car group serving 16 floors. Could it be that during moderate traffic the time-dependent service qualities of the 6-car group are superior? The RTT matrices below can answer this question.

Round Trip Time (RTT) matrix for round trips over full building height. Floors served: 12.																	
Number	Sum of		Total of all passengers transported during round trip														
of add.	all															Ch17dia2	
stops	DDFT's	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	54.4	56.4	58.4	60.4	62.4	64.4	66.4	68.4	70.4	72.4	74.4	76.4	78.4	80.4	82.4	84.4	86.4
1	62.4	64.4	66.4	68.4	70.4	72.4	74.4	76.4	78.4	80.4	82.4	84.4	86.4	88.4	90.4	92.4	94.4
2	70.4	72.4	74.4	76.4	78.4	80.4	82.4	84.4	86.4	88.4	90.4	92.4	94.4	96.4	98.4	100.4	102.4
3	78.4	80.4	82.4	84.4	86.4	88.4	90.4	92.4	94.4	96.4	98.4	100.4	102.4	104.4	106.4	108.4	110.4
4	86.4	88.4	90.4	92.4	94.4	96.4	98.4	100.4	102.4	104.4	106.4	108.4	110.4	112.4	114.4	116.4	118.4
5	94.4	96.4	98.4	100.4	102.4	104.4	106.4	108.4	110.4	112.4	114.4	116.4	118.4	120.4	122.4	124.4	126.4
6	102.4	104.4	106.4	108.4	110.4	112.4	114.4	116.4	118.4	120.4	122.4	124.4	126.4	128.4	130.4	132.4	134.4
7	110.4	112.4	114.4	116.4	118.4	120.4	122.4	124.4	126.4	128.4	130.4	132.4	134.4	136.4	138.4	140.4	142.4
8	118.4	120.4	122.4	124.4	126.4	128.4	130.4	132.4	134.4	136.4	138.4	140.4	142.4	144.4	146.4	148.4	150.4
9	126.4	128.4	130.4	132.4	134.4	136.4	138.4	140.4	142.4	144.4	146.4	148.4	150.4	152.4	154.4	156.4	158.4
10	134.4	136.4	138.4	140.4	142.4	144.4	146.4	148.4	150.4	152.4	154.4	156.4	158.4	160.4	162.4	164.4	166.4
11	142.4	144.4	146.4	148.4	150.4	152.4	154.4	156.4	158.4	160.4	162.4	164.4	166.4	168.4	170.4	172.4	174.4
	54.4	seconds is the total of the DDFT's of non-stop trips from floor zero to floor 12 and back to floor zero.															

We assume that during specific traffic conditions the cars serving 12 floors transport 3 UP passengers and 3 DOWN passengers making 2 additional stops during the UP trip (total number of stops for UP trip = 3) and 3 additional stops during the DOWN trip. The reversal floor is assumed to be the top floor.

The next matrix is valid for a 6-car group serving 16 floors of an otherwise identical building. If we assume similar traffic conditions the 6-car group may transport 4 UP passengers and make 3 additional stops during the UP trip and 4 additional stops for 4 DOWN passengers during the DOWN trip. The reversal floor is assumed to be the top floor.

Round Trip Time (RTT) matrix for round trips over full building height. Floors served: 16.																	
Number of add. stops	Sum of all DDFT's	Total of all passengers transported during round trip													Ch17dia3	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	67.2	69.2	71.2	73.2	75.2	77.2	79.2	81.2	83.2	85.2	87.2	89.2	91.2	93.2	95.2	97.2	99.2
1	75.2	77.2	79.2	81.2	83.2	85.2	87.2	89.2	91.2	93.2	95.2	97.2	99.2	101.2	103.2	105.2	107.2
2	83.2	85.2	87.2	89.2	91.2	93.2	95.2	97.2	99.2	101.2	103.2	105.2	107.2	109.2	111.2	113.2	115.2
3	91.2	93.2	95.2	97.2	99.2	101.2	103.2	105.2	107.2	109.2	111.2	113.2	115.2	117.2	119.2	121.2	123.2
4	99.2	101.2	103.2	105.2	107.2	109.2	111.2	113.2	115.2	117.2	119.2	121.2	123.2	125.2	127.2	129.2	131.2
5	107.2	109.2	111.2	113.2	115.2	117.2	119.2	121.2	123.2	125.2	127.2	129.2	131.2	133.2	135.2	137.2	139.2
6	115.2	117.2	119.2	121.2	123.2	125.2	127.2	129.2	131.2	133.2	135.2	137.2	139.2	141.2	143.2	145.2	147.2
7	123.2	125.2	127.2	129.2	131.2	133.2	135.2	137.2	139.2	141.2	143.2	145.2	147.2	149.2	151.2	153.2	155.2
8	131.2	133.2	135.2	137.2	139.2	141.2	143.2	145.2	147.2	149.2	151.2	153.2	155.2	157.2	159.2	161.2	163.2
9	139.2	141.2	143.2	145.2	147.2	149.2	151.2	153.2	155.2	157.2	159.2	161.2	163.2	165.2	167.2	169.2	171.2
10	147.2	149.2	151.2	153.2	155.2	157.2	159.2	161.2	163.2	165.2	167.2	169.2	171.2	173.2	175.2	177.2	179.2
11	155.2	157.2	159.2	161.2	163.2	165.2	167.2	169.2	171.2	173.2	175.2	177.2	179.2	181.2	183.2	185.2	187.2
	67.2	seconds is the total of the DDFT's of non-stop trips from floor zero to floor 16 and back to floor zero.															

The RTT of the 4-car group is 106.4 seconds and the theoretical minimum INTERVAL 26.6 seconds. Theoretical minimum AWT is **13.3 seconds**.

The RTT of the 6-car group is 139.2 seconds and the theoretical minimum INTERVAL 23.2 seconds. Theoretical minimum AWT is **11.6 seconds**.

The longest UP trip for the 4-car group is 27.2+3+2x8 = 46.2 seconds
(27.2 for non-stop up trip, 3 for disembarkation and 2x8 for additional stops)
The longest DOWN trip for the 4-car group is 27.2+3+3x8-9.6 = 44.6 seconds
(The minus 9.6 is based on the assumption that the first DOWN passenger enters the car one floor below the top floor)
The longest ATTC for passengers of the 4-car group is **45.4 seconds**,

The shortest UP or DOWN trip for the 4-car group is 9.6 seconds
The ATTC for the 4-car group is 45.4 + 9.6 divided by 2 is **27.5 seconds**.

The **ATTD of the 4-car group** is AWT + ATTC = 13.3 + 27.5 = **40.8 seconds**.

The longest UP trip for the 6-car group is 33.6+4+3x8 = 61.6 seconds
The longest DOWN trip for the 6-car group is 33.6+4+4x8 –9.6 = 60.0 seconds
The longest ATTC for passengers of the 6-car group is **60.8 seconds**

The shortest UP or DOWN trip for the 6-car group is 9.6 seconds
The ATTC for the 6-car group is 60.8 + 9.6 divided by 2 is **35.2 seconds**.

The **ATTD of the 6-car group** is AWT + ATTC = 11.6 + 35.2 = **46.8 seconds**
The above comparison shows that the theoretical minimum AWT of the 6-car group is 1.7 seconds shorter but its ATTD is 6 seconds longer than the 4-car group.

Although this comparison is simplistic it does support the conclusion of Chapter 6: A group with 6 large cars does not improve service qualities during light traffic conditions. Traffic simulation can give exact answers to questions of this nature.