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Overgård, Christian Hansen; Vuk, Goran; Nielsen, Otto Anker

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The Ørestad Traffic Passenger Demand Model, version 5.0

Goran Vuk[1], Christian Overgaard Hansen[2] and Otto Anker Nielsen[2]
[1]Danish Transport Research Institute; [2]Centre for Traffic and Transport at DTU

Key words: travel matrices, disaggregate data, VOT, tour modelling

Abstract. Vuk and Hansen ("Validating the passenger traffic model for Copenhagen", Transportation, Volume 33, Issue 4, Page 371-392. 2006) have validated the present version of the Ørestad traffic model (version 4.0 from summer 2000) and concluded that a major drawback of the model is outdated base 1992 matrices. With respect to planning of the alignment of the Metro's phase 4, the so called Metro City Ring, a group of clients headed by the Ministry of Energy and Transport wished to upgrade OTM 4.0 to a new version, ver. 5.0, where a number of improvements were proposed. Most importantly the OTM 5.0 includes new base 2004 matrices. The main aim of the paper is to provide a description of the new base matrices as well as changes in the model estimations.

1 INTRODUCTION

The Ørestad Traffic Model (OTM) is an operative traffic model for the Greater Copenhagen Area (GCA). The OTM consists of demand and assignment models for both passenger and freight transport. The first version of the model was developed in 1994. Since then the model has been continuously improved, latest in summer 2000.

Improvement of the model version from 2000 into OTM ver. 5.0 started in January 2005 and the model is expected to be finalised in September 2006. In the two year period three main types of improvements have been performed. First, base matrices were updated from 1992 to 2004. Second, the demand sub-models were re-estimated. Finally, changes in the model zone structure, road and public transport networks and zone data were made.

The main aim of the paper is to present the new base 2004 matrices (chapter 2) and the estimation results of the passenger demand sub-models (chapter 3).

2 NEW BASE MATRICES

2.1 Introduction

OTM 5.0 base travel matrices describe an average weekday in 2004 in the GCA, which is split between 818 internal zones. There are further 17 port zones defined in the model. An average weekday is defined as Monday-Friday for a year where June, July and August are excluded.

Base 2004 matrices are split by travel mode, travel purpose and time periods. There are five main travel modes: Walk, Bicycle, Car driver, Car passenger and Public transport. Further, there are six travel purposes: Home-Work (HW), Home-education (HE), Home-shopping (HS), Home-leisure (HL), non home based leisure (nHL) and Business (BS). Finally, the time periods defined in the model are following: 05-07, 07-08, 08-09, 09-15, 15-18, 18-21 and 21-05 (in total seven time periods).

The OTM 5.0 works therefore with 5 x 6 x 7 = 210 base 2004 travel matrices. All home-based matrices are tour matrices (GA matrices) while the nHL and BS matrices are trip matrices (OD matrices).

2.2 Data background

Data source in the OTM 5.0 travel matrices are TU data for years 1997-2003 and 2005 (newly completed interviews), and 2005 postcard data.

For a reason that the OTM 5.0 will be applied for planning of the Metro's phase 4 (Metro City Ring) it was decided that the stratification of the 2005 TU interviews should mainly cover the alignment of the new metro line, i.e. most new interviews were completed with respondents living in the Copenhagen and Frederiksberg municipalities. In total there were completed 16.350 interviews in 2005, which include 60.855 records (observations). When corrected for errors 16.285 interviews and 60.542 records were included in the matrix estimation process. An average trip rate for the 2005 TU respondents was 3.64.

1997-2003 TU data includes 15.527 interviews and 46.539 records. The average trip rate for these interviews was 2.90, and it varied between 2.60 in 2001 and 3.10 in 2002.

The postcard analysis was completed in March 2005 where over 61.000 postcards were handed to train, bus and metro passengers, car users and bikers travelling across Søsnittet, a corridor placed in the central part of Copenhagen. 18.376 postcards were successfully coded in a data file, where a main obstacle was to identify addresses. When expanded for an average weekday (based on traffic counts), the survey gave in total 853.663 personal trips across the corridor.

The TU data and postcard data were applied for producing the initial base matrices. In order to produce final base matrices it was necessary to collect 2004 traffic counts for all travel modes. Therefore, traffic counts for cars, vans/lorries, train, bus, metro and bike was the last source of data when building the OTM 5.0 base travel matrices.

2.3 Matrix estimation

The total of 107.000 trips represented in the project's TU data gives an average of 0.15 trips for each zone pair between the 818 internal zones. If decided to build a 818x818 zone matrix would result in a number of matrix cells with zero trips. It was therefore decided to aggregate 818 zones into 90 larger zones based on a number of assumptions. With only 90x90 cells there are in average 13 trips per zone combination. When this was done it was observed that 7% of zone combinations had zero trips.

When the TU trips were assigned to the 90x90 matrix and expanded using the available weight factors it was observed 4.932.273 internal trips. Those trips do not include trips made by persons who temporarily live in the GCA, trips where either O or D, or both O and D lie outside the GCA, and trips made by children below 8 years of age.

<u>Trip matrices across Søsnittet</u>
Out of the total 18.376 postcards available in the project, 11.358 postcards (62%) describe trips between zones within the GCA. When these trips were expended by apply traffic counts we got in total 503.899 trips across the Søsnittet. Table 1 shows how these trips are split between five travel modes and six travel purposes.

Table 1 – Weekday trips within the GCA for zone pairs across Søsnittet based on postcard data, 2004

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	1.823	599	1.643	2.056	1.643	382	8.146
Bicycle	57.011	11.526	3.752	20.379	15.870	4.507	113.045
Car, driver	52.165	3.141	5.827	28.701	18.254	18.066	126.154
Car, passenger	12.363	1.199	5.645	22.696	9.554	5.490	56.947
Public transport	105.790	17.745	9.526	34.286	22.478	9.782	199.607
Total	229.152	34.210	26.393	108.118	67.799	38.227	503.899

Table 1 can be reproduced with the available TU data. The result is shown in table 2.

Table 2 – Weekday trips within the GCA for zone pairs across Søsnittet based on TU data, 2004

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	2.457	1.096	4.140	9.279	7.196	587	24.755
Bicycle	38.153	14.318	9.166	24.631	22.398	4.077	112.743
Car, driver	32.383	1.633	8.303	27.804	22.518	17.147	109.788
Car, passenger	3.815	1.320	2.242	10.301	4.997	2.295	24.970
Public transport	59.134	15.265	21.305	38.474	25.727	5.105	165.010
Total	135.942	33.632	45.156	110.489	82.836	29.211	437.266

As expected, the postcard total is in favour of the TU total because it includes trips made by children under 8, it includes trips made by tourists and people who live temporarily in the GCA, and because the BS trips are better described in the postcard data then in the TU data.

Trips presented in table 1 origin in 11.400 trips from the postcard survey while the trips presented in table 2 origin in 14.700 trips from the TU data. The statistical error in the two data sources was judged to be the same because of what it was decided to combine the two sources when calculating zone-to-zone trips over Søsnittet based on the following assumptions: a) walk trips were judged to be correct in the TU data, b) trip totals for other travel modes than walk were judged to be correct in the postcard data, c) the ratio between the travel mode totals for postcard data and TU data (factors are over 1.0) are applied in table 2 for all cells (though not for walk mode). The results of the combination of the postcard and TU data are shown table 3.

Table 3 – Weekday trips within the GCA for zone pairs across Søsnittet, 2004

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	2.457	1.096	4.140	9.279	7.196	587	24.755
Bicycle	47.633	12.941	6.472	22.538	19.165	4.297	113.045
Car, driver	44.688	2.509	7.684	30.325	22.064	18.885	126.154
Car, passenger	10.531	2.104	5.380	23.094	10.475	5.363	56.947
Public transport	88.661	18.105	17.649	40.413	26.799	7.979	199.607
Total	193.971	36.755	41.324	125.648	85.699	37.111	520.508

Trip matrices for the rest of the GCA

To take account for tourists etc. the zone-to-zone TU trips not included in table 3 are expanded by applying the experience from the postcard survey as explained above. Table 4 shows trips within the GCA, i.e. omitting external trips, split by travel modes and trip purposes.

Table 4 – Weekday trips within the GCA, 2004

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	51.285	89.059	310.678	349.350	162.704	11.852	974.927
Bicycle	252.207	184.082	178.620	288.696	151.981	25.360	1.080.946
Car, driver	518.886	33.306	375.362	601.359	335.293	152.619	2.016.824
Car, passenger	127.152	69.628	183.904	402.463	148.445	40.893	972.486
Public transport	276.351	124.666	117.765	1.96.003	105.345	23.847	843.977
Total	1.225.881	500.741	1.166.329	1.837.870	903.768	254.571	5.889.160

When the external traffic is included we get the final GCA travel matrices as shown in table 5.

Table 5 – Weekday trips including the external traffic, 2004

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	51.285	89.059	310.678	349.350	162.704	11.852	974.927
Bicycle	252.207	184.082	178.620	288.696	151.981	25.360	1.080.946
Car, driver	559.776	37.545	393.361	649.925	355.994	168.199	2.164.799
Car, passenger	135.330	71.324	200.103	465.599	162.936	45.567	1.080.859
Public transport	298.929	137.678	121.552	219.528	111.130	32.434	921.251
Total	1.297.527	519.688	1.204.313	1.973.097	944.745	283.412	6.222.782

2.4 Matrix adjustment

Matrix adjustment is applied on car and public transport matrices based on the existing traffic counts for 2004. There are three reasons for that. First, the TU data applied in the project relates to the period 1997-2005 while the counts are collected for 2004, which is the model base year. Second, there was not enough information in the TU data and postcard data to split the 90x90 zone matrices into 818x818 zone matrices without introducing large statistical errors. Finally, the TU data does not include information about the travellers living outside the GCA, which minimises information about the external trips.

Matrix adjustment of the car traffic

For the purpose of matrix adjustment of car matrices it was colleted 2.193 counts from the Danish Road Directorate and the Municipalities across the GCA. Lots of efforts were put into the quality insurance of the received counts.

We started by assigning the matrices as shown in table 5 on the road network and comparing them to the available road traffic counts. Some general deviations were noticed, e.g. the traffic was underestimated across the island of Amager as well as on the corridor of Motorring 3, while it was overestimated on the main access roads towards the city. Therefore, before the matrix adjustment was started the existing matrices were corrected for the above described tendencies.

The new van and lorry matrices originate from the OTM 4.0 van and lorry matrices adjusted for the new zone system and day periods.

The new matrices for the external traffic are based on traffic counts.

The Multiple Path Matrix Estimation Method

The matrices described in 2.3 are OD trip matrices that can be assigned to the road network and therefore compared to traffic counts on the link level. Each road link gives traffic for a number of zone combinations while the traffic for a specific zone-to-zone combination can be assigned to a number of routs (especially in the urban areas). Note also that traffic counts are not split by travel purpose as the matrices are.

The matrix adjustment applied in the project is a so called Multiple Path Matrix Estimation Method (MPME), developed by Nielsen ("Two new methods for estimating Trip Matrices from Traffic Counts". Chapter in Travel Behaviour Research: Updating the state of play. Edited by Ortúzar, H. D., Hensher, D & Jara-Díaz, D. Elsevier Science Ltd. 1998. pp. 221-250). The MPME is a heuristic method, which simultaneously re-estimates the matrix while the car assignment model iterates. The method ensures that the model calculated link traffic is a weighted average discrepancy relative to the available link traffic counts. At the same time the method ensures that the OD calculated traffic is a sum of link traffic for the available routes between zone pairs, where to each route it is attached the probability of being applied. The method converges when the square of discrepancy between the counted and estimated (calculated) traffic is below a certain (predefined) threshold.

When zone-to-zone traffic is calculated, the original matrix is adjusted in a heuristic way where the square discrepancy between the original matrix and the new matrix minimizes. The method therefore fits the available counts as good as possible to the matrix while changing the original matrix least possible.

The more iterations the better matrices fit to the observed traffic. However, if the number of counts is not optimal (i.e. not enough counts for an area) the matrices can be adjusted wrongly if running with many iterations. In conclusion, we run three iterations when adjusting the car matrices as it was judged that the base matrices were accurate. Each time the matrix was adjusted we assigned them to the road network and compared the observed to the assigned traffic.

The adjustment was applied on car matrices split by seven day periods.

Once we were satisfied with the obtained matrix adjustment, the matrices were changed into car traveller matrices (and not vehicles), they were made symmetrical and finally they were made to be GA matrices for the model segments which were home-based (see chapter 2.1).

The adjustment of car matrices based on traffic counts resulted in a small total correction of trips by 1%. However, there were made larger changes of the 5-7 a.m. and 9 a.m. – 3 p.m. matrices, which had to be enlarged. Opposite to that, the 6 p.m. – 9 p.m. matrix and the 9 p.m. – 5 a.m. matrix had to be minimised substantially. Van traffic was enlarged by 4% while the lorry traffic was minimised by 21%. This strong correction of the lorry traffic origins in a different definition of what lorry is in the two projects.

<u>Matrix adjustment of the public transport</u>
The bus, train and metro counts were collected from the operators (i.e. HUR, DSB and Ørestadsselskabet).

The bus counts were collected for November 2004 and they were corrected in order to represent the average weekday (in the OTM we exclude June, July and August when calculating the average annual weekday). The bus counts referred to station-counts for all bus lines in the GCA, split by 7 time periods. The train counts were based on so called 2004 Østtællinger (train postcard analysis completed in the first Thursday of November). The metro counts referred to the November 2004 counts. Both the train and metro counts were adjusted to account for the average weekday in 2004.

A similar method described for the adjustment of the car matrices was applied in the public transport matrices based on the available public transport counts, i.e. the matrices were assigned to the network and compared to the available counts. There is however one important methodological difference between the two types of adjustments, i.e. the public transport matrix adjustment lies on the station level while the car matrix adjustment lies on the link level. In the applied public transport matrix adjustment method we calculated adjustment factors, which after words were corrected manually taking into consideration for some specific local traffic conditions. A common reason for need for manual corrections is that the number of interchanges when travelling from O to D by public transport is not known in counts.

The public transport assignment method applied in the matrix adjustment is based on the actual bus and train timetables. It is a stochastic assignment model, which considers distributed values of travel time. The method is described in Nielsen, ”A Stochastic Transit Assignment Model Considering Differences in Passenger Utility Functions”, Transportation Research Part B Methodological, Vol. 34B, no. 5, pp 337-402, Elsevier Science Ltd.

Final day matrices

Table 6 shows the final 2004 day matrix after the matrix adjustment was finalised.

Table 6 – Final base day matrix 2004 (Observed matrix)

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	51.285	89.059	310.678	349.350	162.704	11.852	974.927
Bicycle	252.207	184.082	178.620	288.696	151.981	25.360	1.080.946
Car, driver	549.634	39.828	395.508	625.148	378.188	192.358	2.180.665
Car, passenger	132.697	77.368	201.808	449.730	172.905	52.081	1.086.589
Public transport	306.010	133.710	127.361	223.403	121.031	35.137	946.654
Total	1.291.833	524.047	1.213.976	1.936.327	986.809	316.789	6.269.781

When executing the OTM 5.0 for the base 2004 year (see chapter 3 for details) the base 2004 day matrix is reproduced. The model predicted 2004 base data matrix is shown in table 7. The cell differences between tables 6 and 7 are small.

Table 7 – Model predicted base day matrix 2004 (Predicted matrix)

Travel mode	HW	HE	HS	HL	nHL	BS	Trips
Walk	51.199	88.848	310.122	348.768	162.541	11.819	973.296
Bicycle	251.877	184.000	178.331	288.494	151.890	25.341	1.079.933
Car, driver	547.740	39.756	395.222	624.286	377.444	191.927	2.176.377
Car, passenger	132.214	77.288	201.572	448.686	172.455	51.945	1.084.160
Public transport	305.747	133.559	127.132	222.932	120.658	34.875	944.903
Total	1.288.777	523.451	1.212.380	1.933.167	984.988	315.907	6.258.669

3 MODEL ESTIMATIONS

3.1 New VOT

Data used in the estimation of the new VOT was from the Danish National Value of Travel Time Project (DATIV) while all SP data completed up to 2000 (applied in the model version 4.0) was judged to be outdated and therefore discarded. The estimation of new VOTs was based upon SP experiment 1, which examines trade-offs between in-vehicle travel time and travel cost for travellers by car, S-train, Re-train and metro, i.e. the SP1 experiment is a within mode experiment. The VOT estimations were carried out on a total of 26,543 observations, where each respondent may be represented by up to 8 repeated observations.

The initial estimations showed a tendency where bus VOT was lower than the metro/train VOT. Explanation to this is twofold: first, an average income of a train traveller is higher than average income of a bus traveller, and second, an average train trip is longer in distance than an average bus trip (VOT projects usually show that the longer trip the higher VOT it is).

As in the travel demand forecasts it is expected that the bus VOT is higher than the metro/train VOT due to the higher discomfort we needed to correct the above presented tendency in the DATIV data. That was done by applying the OTM 4.0 VOT where all non-train VOT were scaled to train VOT. Table 8 shows the proposed OTM 4.0 VOT scaled to train in-vehicle time.

Table 8 – VOT scaled to train in-vehicle time

	HW	HE	HS	HL	nHL	BS
Train	1.0	1.0	1.0	1.0	1.0	1.0
Bus	1.5	1.0	1.0	1.7	1.7	1.5
Metro	0.7	1.0	1.0	1.4	1.4	0.7
Light rail	1.0	1.0	1.0	1.4	1.4	1.0

where HW home-work segment, HE home-education segment, HS home-shopping segment, HL home-leisure segment, nHL non-home based leisure segment, BS business segment.

In the subsequent DATIV estimation one PT VOT was estimated per trip purpose segment. That VOT was then multiplied by constants as presented in table 8 in order to produce new VOT. OTM 5.0 values of travel time are presented in table 9.

Table 9 – OTM 5.0 values of travel time in 2004 values

	HW	HE	HS	HL	nHL	BS
Train	21.3	23.3	16.5	16.9	14.0	85.7
Bus	32.0	23.3	16.5	28.7	23.8	128.6
Metro	14.9	23.3	16.5	23.6	19.6	60.0
Light rail	21.3	23.3	16.5	23.6	19.6	85.7
Car free flow	33.5	24.4	14.9	26.4	24.5	46.8
Car congested	69.4	24.4	14.9	71.6	54.4	130.8

The VOT presented in table 9 are related to income group DKK 0-200.000 (personal gross 2004 income). VOT increases with the income in the following ratio relative to figures presented in table 2: for income group DKK 2-300.000 the ratio is +1.27, for income group DKK 3-400.000 the ratio is +1.60, for income group DKK 4-500.000 the ratio is +1.93, and for income group DKK 500.000 and above the ratio is +1.98. This is to say that for those earning more than DKK 500.000 the VOT is twice as high as for those earning up to DKK 200.000 a year.

Values of travel time for components waiting/transfer time, access/egress time, car parking searching time, bicycle travel time and walk time are calculated applying 2003/2005 TU data (those components do not exist in the DATIV data) combined with LOS files. The RP estimations were performed in the way that the DATIV VOT were all converted into the car free-flow time. For instance train travel time component in the HW-segment was included in the utility as *ff_coeff * 21.3/33.5 * train_travel_time*. The coefficient to be estimated is car free-flow time (ff_coeff).

3.2 Generation model

The generation model works at the level of an individual and it predicts a number of tours/trips generated by an individual in an average weekday. It is a binary choice logit model with alternatives "stay at home" and "make a tour/trp".

Three sets of variables are included in the generation model in a following order: Occupation type variables, Car ownership variables, and Personal income variables.

For the occupation type variables, it was important to specify variables that can be implemented using the available zonal data (to allow for forecasts).

Car ownership variables were specified and tested in two ways:

- cars per household member, and
- car availability variable, applied if an individual had license and a household had at least one car.

Tests of cars per household member did not yield significant results. However a number of significant and plausible car availability variables were identified and have been retained in the models. Car availability segments cannot be forecasted directly from the available zonal data. Therefore analysis was undertaken using the base year data to relate the available information from the zonal data (cars per 1000 inhabitants) to the car availability segments specified at the individual level. In application these relationships were used to determine the distribution over car availability segments for each zone.

The final set of variables tested were for gross personal income, which is available split by 11 personal income bands from the zonal data file. The effect of income was tested after car ownership, as concerns were raised as to possible correlations between these variables.

3.3 Destination / mode choice model

In the OTM 5.0 the destination choice / mode choice model is estimated simultaneously in a tree structure. For each model segment the structure was tested for the following three possibilities: 1. mode and destination choice considered in parallel, 2. mode choice under destination choice (e.g. home-work segment), and 3. destination choice under mode choice (e.g. home-shopping segment).

Three sets of parameters were estimated in the destination / mode choice models:

1. extra VOT as described in 3.1,
2. car availability parameters, and
3. mode specific constants.

Three travel mode availability parameters were estimated: PTCarAv, CarDcarhh and CarPcarhh. The PTCarAv parameter reflects a lower probability of choosing PT for individuals who have a car available. The CarDcarhh and CarPcarhh parameters predict a higher probability of choosing car driver / car passenger as the number of cars per person in the household increases. These two parameters can be interpreted as car availability parameters.

Four mode specific constants were estimated relative to car driver alternative, i.e. public transport, car passenger, bicycle and walk.

3.3.1 Model elasticities

Elasticity runs have been determined using the unweighted sample used for model estimation, i.e. these are not the final model elasticities. Four policy runs have been made to determine elasticity values:

P1: 10% change in car costs
P2: 10% change in car time
P3: 10% change in PT costs
P4: 10% change in PT in-vehicle time

The demand elasticity values for the HW model are presented in table 10 where the direct demand elasticities are highlighted in bold.

Table 10 - Demand elasticity vales for the HW segment

	Car Cost	Car Time	PT Cost	PT Time
PT	0.053	0.174	**-0.411**	**-0.397**
Car Driver	**-0.116**	**-0.319**	0.076	0.084
Car Passenger	0.110	**-0.420**	0.163	0.162
Cycle	0.054	0.186	0.168	0.156
Walk	0.046	0.151	0.147	0.122

The public transport direct elasticities are higher than car direct electicities. While the PT direct cost elasticity is higher than the PT time direct elasticity the opposite is correct for the car modes. Across elasticites are always lower than the direct elasticities. Car passengers are more sensitive to worsening of car travel time than the car drivers. Finally, for the increase of car travel costs the car driver direct elasticity is negative (as expected) while the car passenger elasticity is actually positive. This is because the car costs are attached to the driver in the model utilities.

3.4 Pivot point method

As seen in chapter 2.4, there is a very small difference between the final observed 2004 base day matrix (see table 6) and the model predicted matrix (see table 7). This is achieved by applying a pivot point procedure in the model application. The method is described in short in this chapter and for more details please refer to Daly, Fox and Tuinenga, "Pivot-point procedures in practical travel demand forecasting" (European Regional Science Association conference in Amsterdam, 2005).

Based on the 2004 files of LOS for all travel modes, model parameters and the official 2004 zonal characteristics the base 2004 synthetic matrices are produced. So for each model run (e.g. 2004 or a future year) the available matrices are the base (observed) 2004 matrices and the 2004 synthetic matrices.

The pivoting procedure is then applied to generate the model forecasts from the synthetic matrices for the base 2004 year S_b, the synthetic matrices from the scenario in question S_f, and the base 2004 matrices B, as $B * S_f / S_b$.

It is not always possible to apply this calculation as simply as stated. First, any combination of the three components may be zero (or very small) making the calculation impossible or meaningless. Second, particularly when there is a land-use change affecting a currently undeveloped zone, the change may be quite extreme and strict application of the formula above can lead to an 'explosion' in the number of trips. Eight possible cases and the recommended treatments are set out in table 11.

Table 11 – Eight possible cases in the pivot point adjustments

Base (B)	Synthetic Base S_b	Synthetic Future S_f	Predicted	Cell type
0	0	0	0	1
0	0	>0	S_f	2
0	>0	0	0	3
0	>0	>0	Normal growth: 0 Extreme growth: $S_f - X_1$	4
>0	0	0	B	5
>0	0	>0	$B + S_f$	6
>0	>0	0	0	7
>0	>0	>0	Normal growth: $B * S_f / S_b$ Extreme growth: $B * X_2 / S_b + (S_f - X_2)$	8

To complete the specification of the calculation it is necessary to specify the X variables, to define when a cell is considered to be zero (a test value is 10^{-3}) and when and how extreme growth (for cases 4 and 8) is to be applied. With respect to the last point, in the extreme growth cases (4) and (8) it can be seen that the standard factor function is used initially, up to the limit when S_f is X_1 (case 4) or X_2 (case 8), and from that point an absolute growth is applied. In case (4) the starting point for absolute growth is 0, in case (8) it is $B * X_2 / S_b$.

The definitions for X_1 and X_2, using factor G, and parameters k_1 and k_2, are given by:

$X_1 = B * G$
$X_2 = S_b * G$
$G = k_1 + k_2 * \max(S_b/B, k_1/k_2)$, where usually $k_1 = 0.5$ while $k_2 = 5.0$

Note that when $B \rightarrow 0$, $X_1 \rightarrow k_2 * S_b$

4 CONCLUDING REMARKS

Updating of the present operational traffic model for the Greater Copenhagen Area (GCA), the OTM 4.0, includes building of new travel matrices for the base 2004 year and re-estimation of the demand passenger model, as the most important improvements.

The project is to be finalised at the moment and we don't know yet how well the matrices fit to the observed traffic once the model is run. The preliminary results are though very encouraging. The methodology applied when building new travel matrices employs completing a large number of personal interviews and postcard surveys, refined zone system, refined number of trip matrices according to trip purposes, refined time-of-day matrices, and matrix adjustment based on traffic counts.

Some very important improvements were done in the model structure. First of all, the whole model is now based on disaggregate data. Second, the destination and modal split models are now joined into one model (in a hierarchical structure), which is believed to model personal behaviour better than when split in two models. Third, both the generation and the destination/modal split sub-models include more variables than the OTM 4.0, e.g. income is now included in both sub-models. The VOT are also updated applying DATIV SP data.

A thorough validation of the new model is needed once the project is completed. Partially, it is important to find out how well the model results fit the observed traffic and partially it is important to see how model reacts in the future scenarios.