Ministry of Transport & Road Safety
Economics and planning department

National Travel Demand Model

Developing and Operating Models For Production-Attraction-Distribution and Traffic Assignment

Abstract

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General Description

The Israeli national travel demand model describes the national trip distribution in 2007. Tl demand was estimated in 3 dimensions – geography, day period type, and transport mo underlying data was collected using state-of-the-art technologies for travel monitoring.

This model is a main contributor for the existing set of transportation planning tools in Is regard to interurban and inter-metropolitan traffic.

The goals of this project were as follows:

- Understanding the present scope and attributes of travel, especially for long- interurban trips in Israel.
- Formulating a travel demand model to enable forecasting of future travel demand ir
- Creating a nationwide travel demand framework that guides, balances and contribu accuracy of metropolitan transportation models in Israel.

A fundamental requirement for constructing a model for these purposes is high-quality info Such information about intercity travel has not been previously available. Even the questions could not be answered. As an example: What is the total passenger traffic (by all modes, including private vehicles) between Haifa and Jerusalem (about 200 kms in le between Beer Sheva and Tel Aviv (about 100 kms in length)? The last Israeli Central B Statistics (CBS) survey, which dealt with such long-distance travel at a reasonable significance was conducted almost 40 years ago, in 1972.

In order to acquire this information, innovative, state-of-the-art data collection technolog used as described in the subsequent sections in this document. The information was formulate and calibrate a transportation model that successfully represented the nation flows (in 2007), and tied it to the properties of the various geographical areas in Israel and attributes of the transport system.

The described model fulfils the major project's objectives: provision of accurate represen travel demand in Israel, with the ability of enabling future national traffic forecasts, for number of future scenario years. This model is also capable of providing MPA's (met planning agencies) with consistent, better information on inflowing, outflowing, and pass traffic.

Surveys and their use in calibrating the model

The model is based on a comprehensive national survey, which monitored travel on the changes in location of cellphones A sufficiently large sample of 10,200 phones, subscrib Israeli "Orange" cellphone company, one of the largest in Israel) was used. The advantag approach is that cellphones, whether silent or in active conversation, are always connect nearest cellphone tower. A moving phone in a vehicle will change the tower to wh connected, as the vehicle moves on an existing roadway. The selection of cellphone towe by the "Orange" network is approximately 2,200, in nationwide coverage.

The survey's duration was of 16 weeks in March - June 2007. Approximately 10,200 ce were sampled each week, and their full location diary was obtained, for a total 1.04 millio days (number of cellphones multiplied by the days of the survey) were recorded. This scope allowed the recording not only the movements at peak hours on weekdays, but at a weekends, and special trips performed during holidays**.** The cellphone tower's widespread distribution allows for full recognition of long journeys, but did not always include shor several miles, (depending on the density of towers, and their available call capacity - if an is fully loaded, the transmission might move to another close by antenna and it will look lik trip has accrued even though the phone has not changed its location).

To our knowledge, this is the first survey of its type in the world that has created a nati table (giving the number of trips between any two analysis zones) using this technology. be noted that this kind of data collection insures that all interurban trips will be covere typical travel habits surveys, where travelers are interviewed and many trips are forgotten reported. However, this method, unlike travel habit surveys, does not allow relating passe travel attributes, nor it can get accurate information on trip purpose, traffic mode, occupancy, etc. Careful analysis of the cellphone data provided us with some of this info but it is neither complete nor accurate.

This survey had a preliminary pilot stage in which a proof-of-concept of the technol established, and its success in tracking trips was demonstrated. A country-wide telephon conducted during April 2007, assessed the extent of cellphones use in the country and in po centers. This survey found that 83% of the people over the age of 8 in Israel are equippe least one cellphone, with an occupancy rate of 92.6% between the ages 18 and 60. An a result of the survey was that cellphones remain in operation 94% of the time. The scope mobile phones, especially in the age groups with the highest propensity of travel makes cellphone movement a very effective means of monitoring travel in the general population.

For the analysis, the country was divided to 585 traffic analysis zones (TAZ). Land use anc data was collected for these TAZ, including the following variables: population by age, nu available vehicles, the existence of significant travel generators, and employment by type.

The survey data was reconstructed as "trips" (phone movements) between zones. A trip defined as a stay of at least 20 minutes in one zone. A trip was defined as a movement lor 10 km. The purpose of this exercise was the estimation of the number of trips leaving and each TAZ and the construction of person-trip table by day period. The data was not enough, so a statistical model was formulated, based on the survey data, to derive day origin-destination matrices from the activity data and the attributes of the survey's trip table

The next step of the analysis was the adaptation of an existing modal split model, which s person trip table into their mode of travel. The model was adjusted to intercity trav aggregate data on road traffic volumes and the number of passengers by utilizing trains ar The mode split model produces three major trip tables: An automobile table and person train and bus. The bus trip table included all non-rail public transport modes, for six day (between 6:00am-01:00am) in a regular weekday.

The trip tables were assigned to the networks using traffic assignment models (EMME highway traffic assignments were validated against both **traffic counts** and **actual travel** highway links. The public transport assignment was validated against passenger data. V correlations were found between the actual observations and the model estimates. We concluded that the model reflects Israel's passenger travel in a reliable and detailed manner

Deleted: a

Two more state-of-the-art surveys were implemented in building and calibrating the model:

- A survey of traffic movements between screenlines and buffers was conducted in M In the survey, the traffic was filmed by more than 100 cameras in 34 stations (screen lines) all over the country. A computerized system of license plate recogni matching gave good information about the trips made by specific cars (if the car wa in more then one station), primarily on long road trips.
- **Vehicle speed survey**: The positions of company-owned vehicles, under 4 tons, with GPS devices were continuously tracked. This technology was instrumental in over 15 million vehicle kilometers across the country in 2005. The survey provided and accurate data on travel speeds on urban and interurban roads alike.

It can be concluded that the model recreated Israel's interurban traffic array accuratel following dimensions, during a 6 day period:

- Country-wide trip tables by mode and time-of-day

- Traffic volumes both on rural roads and major roads
- Passenger volumes on rail lines

The model and the data can be used for a number of purposes:

- Preparing national transportation plans
- Evaluating proposed construction projects on the country’s road and rail networks.
- Providing the MPA's with consistent data on traffic inflows, outflows, and thru traff

Main results

Travel volume:

- Trips made (trips per day per person over the age of 8):
  - On an average weekday (Sunday - Thursday) 2.00 trips are made
  - On Friday approximately 1.28 trips are made
  - On Saturday 1.00 trip are made.
- The average trip lengths (for trips longer then 10 km):
  - On an average weekday (Monday - Thursday) 17.5 km
  - On Sunday 18.2 km
  - On Friday 16.6 km
  - On Saturday 19.4 km
- The longest average trips are created on Sundays between 5-7 am (22 km).
- About 0.7 short local trips per day should be added to the above trips (most of shorter than 5 km). This travel layer was not identified in the phone's survey dat trips are not included to the person trip tables.
- The number of daily trips longer than 100 km are (in thousands):
  - On Sunday - 249
  - Monday – Thursday - 222
  - Saturday - 190

Table A presents the numbers of non local trips in 2007 from the survey.

Table A - The scope of the non local travel by days of the week and by length (in thous

Length (km)	Total trips				Percentage distribution			
	Sunday	Monday-Thursday	Friday	Saturday	Sunday	Monday-Thursday	Friday	Satı
0	6,518	6,583	4,498	3,323	54.27	54.89	58.34	5
10	2,413	2,384	1,464	1,162	20.09	19.87	18.99	1
20	1,141	1,158	675	543	9.50	9.65	8.75	9
30	626	641	350	291	5.22	5.35	4.54	4
40	364	350	193	158	3.03	2.92	2.50	2
50	258	248	143	123	2.14	2.07	1.85	2
60	192	182	100	96	1.60	1.51	1.30	1
70	98	88	55	54	0.82	0.73	0.72	0
80	81	75	42	42	0.68	0.63	0.54	0
90	68	63	38	38	0.57	0.52	0.49	0
100	249	222	152	190	2.08	1.85	1.97	3
Total	**12,009**	**11,994**	**7,711**	**6,021**	**100**	**100**	**100**	**1**

- Traffic between main population centers on an average weekday (Sunday – Thursda
  - Between Jerusalem and Gush Dan **-** about 29,000 trips a day per direction,.
  - Between Haifa **-** “Ha’Krayot” and Gush Dan **-** about 13,000 trips a day per d
  - Between Haifa **-** “Ha’Krayot” and Jerusalem **-** about 2,200 trips a day per di
  - Between Beer Sheva and Gush Dan **-** about 4,800 trips a day per direction,

These numbers are about 38% higher **per capita** than the estimates from the CBS's 1996/9 habits survey".

Research findings

The trip end models, both for generated and attracted trips are of the following functional fc

$$t_i = a + b * Rm_i + c * W_i$$

$$T_i = P_i * t_i$$

Whereas:

t_i - the number of trip ends per person aged 8 and older, for the i-th TAZ,
Rm_i - the motorization rate of the i-th TAZ,
W_i - the i-th TAZ's employment ratio (equal to the number of jobs in the zone divided by th population aged 8 and older).
T_i - the number of trip ends in the TAZ,
P_i - the population aged 8 and older.
a,b,c – regression parameters

Tables B and C present the model parameters for trip production and attraction. Also prese statistical measures of the parameters' statistical significance and the models' goodness-of-fi

Table B – Estimated model parameters for generated trips by day perio

Day period	Regression estimates			t-statistics			]
	c(W)	b(Rm)	a	c(W)	b(Rm)	a	
Morning 6-9		0.000151	0.07265		6.8		0.6
Morning 9-12	0.08455	0.00008	0.03	8.4	3.7	5.1	0.8
Noon 12-15	0.1627	0.000071	0.0178	10.2	2.1	1.9	0.
Afternoon 15-19	0.1896	0.000113		13.4	5.3		0.8
Evening 19-22	0.0987	0.00001	0.0137	8.3	3.8	2	0.8
Night 22-01	0.00344	0.000029	0.0182	5.1	2	4.6	0.
Total	**1.939**	**0.001646**	**0.691**	**10.1**	**4**	**6.2**	**0.8**

Table C - model parameters for attracted trips by day periods

Day period	Regression factors			t statistic factors			
	c(W)	b(Rm)	a	c(W)	b(Rm)	a	
Morning 6-9	0.18443	0.000115		13.2	5.2		0.
Morning 9-12	0.1083	0.00006	0.0249	9.5	2.5	3.7	0.
Noon 12-15	0.0951	0.000078	0.0463	8.9	3.4	7.4	0.
Afternoon 15-19	0.0709	0.000146	0.047	5.9	5.7	6.7	0.
Evening 19-22	0.0448	0.000091	0.04	4.5	4.3	6.8	0
Night 22-01	0.0214	0.0000183	0.027	3.1	1.3	6.7	0.
Total	**1.939**	**0.001646**	**0.691**	**10.1**	**4.0**	**6.2**	**0.**

From the above tables we can ascertain the following conclusions:

- The zonal population over the age of 8, the rate of motorization of the populatior number of jobs available in the zone provide good estimates of the number of per leaving and entering the zone in each day's period
- The relative importance of these factors varies by day period. Trips arriving at a cert in the morning are explained mainly by the number of jobs available in that area, w departing from the TAZ in the morning are mainly explained by its popula motorization rate.
- Later in the day, trips are generated by the people leaving their work and trips attra TAZ are made by people returning home.

- The number of person-trips generated grows with the motorization rate. However, a
  the morning, zones with very low motorization rate generate a relatively high nu
  trips per person.

Findings from the model validation and from the modal split model

- During the morning peak (average for 6-9 am) 57.6% of the trips are performed in
  car, 1.2% in a train, and 41.2% by non-rail public transport (buses, taxis of all ki
  special means of transit like employer-provided transport).

- Approximately 67% of all trips in a day (all periods) are made by private cars, less
  by rail and 32% by non-rail public transport.

- Travel speed in getting to metropolitan centers on interurban roads average betwe
  km/h during the morning peak (with a standard deviation of 5-10 minutes). The
  include the following:

  - The major entry-point to Jerusalem on Road No. 1 (Jerusalem-Tel Aviv H
    from Harel Interchange to Saharov junctions (before the opening of Highway
  - One of the major entry-points to Tel-Aviv on Road No. 1 from S
    Interchange to Kibbutz Galuyot Interchange;
  - Another major entry-point to the Tel Aviv metropolitan area - Road No. 4
    Holot and Ganot Interchanges.
  - A major entry-point to the Haifa metropolitan area – Road No. 4 from Ak
    Checkpost Interchange.

- The average speed on interurban roads, including urban major roads between 6-9 a
  morning, is about 42 km/h. This speed does not weigh in the lower speeds on the f
  road's network. Between 9-12am the average speed rises only slightly to 47 km/h.

- In the network analysis two sets of volume-delay functions were utilized:

  - One set of functions for the assignment model, which estimated link volume
    functions over-estimate travel times of congested links (Volume Capacity (V
    greater than 1).
  - The other set provides unbiased travel time estimates. The correct travel t
    used for the modal split model and for reporting travel times. It should be n
    in trying to run the assignment model with these functions resulted in an e
    traffic assignment.

- The model includes time penalties to represent the tolls on Highway No. 6, also k the Cross-Israel Highway.

- During the course of validating the traffic assignments, an addition of 20% of sh (less than 10 kms. in length) to the origin-destination matrices, was deemed necessa addition compensates the cellphone survey's failure in identifying the necessary vo short trips.

Products and Uses

- **<u>This project has created a geographical basis for national traffic analysis</u>**. 58 zones were designed to fit to all existing metropolitan models. Basic data for the year each traffic zone was collected (from CBS and other sources) or estimated (populati employees, motorization rate etc.).

- The model with all its components is the **<u>basis for traffic forecasts that are prepa for the year 2040</u>**.

- The model will be used as a **<u>background for the validation of the "base year"</u>** - in interurban roads and interurban public transportation. For this purpose, origin-de matrices are attached to this report.

- **<u>The model's data are available to MPA's for improving their models</u>** regardin inflows, outflows and thru traffic for the relevant metropolitan areas

- **<u>It is possible to use the model for examining transportation policy issues</u>** a theoretical influence on traffic characteristics in the year 2007. For instance – the in changes in fuel taxation, changes in motorization rate, different employment distributio

Other potential uses for the collected data and recommendations for development

- **<u>The database colleted in this project can be used for other transportation resea model development:</u>**

  - Understanding trip chaining and tour production - it should be noted that du work process there was an attempt to develop a tour model, however, the mod of explanation was found not sufficient and a standard 4-step trip-based mo chosen. A tour model has many advantages in understanding and explaining tra development of such a model based on cellphone data requires additional inv An area for further analysis is improving the accuracy of locating the phones.

- o Understanding profiles of commuting trips and the regional connections r these trips.
- o Understanding special trip characteristics for the different parts of the week periods and holidays. This area is beyond the current project's scope.
- o The possibility of developing tools for identifying trip mode for individual trips

- Data collection methods developed in this work, especially surveying travel by c movements, can be a reliable tool for updating the national traffic data every few should be noted that the ability to describe accurately the positions of phones i better and faster, and it seems that in the near future it would be possible to identify trips of several kilometers.

- It is important to find a way, of combining the reliable automated data c technologies, as done in this work, with "conventional" data collection method utilize interviews of the person performing the trip, his/her travel habits, travel mod trip purposes, etc. Knowing the trips' and travelers' characteristics, their ne preferences, together with accurate information on the number of trips, their timing, etc. accurately recognizing the scope of travel, its timing, its route etc., b technologies that **are not** dependent on information from the interviewees, can forr of a transportation planning process which can examine various policy issues (price congestion tolls, parking policies and more).

- Continuing use of trip information from car fleets equipped with GPS units in continuously calculate travel speeds in the road network. These data can support for identifying service failures in the highway system.