Workshop on project preparation process
with reference to EU and WBIF requirements

Demand Modelling

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European Commission

Demand Modelling (transport model)

Purpose	Forecasting the demand of transport services, which could serve for determining the effects of implementing one or another infrastructure measure
Conditions	Sufficiently well defined alternatives
Results	Forecasted transport flows for the reference period for “with project” and “without project” scenarios
Timing	As part of the feasibility study

Definitions and concepts

- *The demand model* forecasts the behavior of the population in terms of number of trips, their origin and destination, mode choice, choice of time and route, etc.

- The models forecast the future demand of transport services depending on the present conditions and forecasted values of social and economic parameters such as population, jobs, GDP, etc.

General information

1.1 New model or model update?

1.2 What modelling software is used?

1.3 What *transport modes* are modelled?

- If the model is an update, incremental improvements may be expected (but also outdated assumptions); a new model may be of uncertain quality
- The modelled transport modes are a main property of the model. E.g. for justification of road projects it is acceptable to use a model covering only road transport

1.4 Is the *base year* recent enough?

1.5 Is there sufficient data available for the base year?

- The *base year* is a past year, which the model is built to represent
- This is the most recent year for which the following data is available:
  - *trip patterns* – through counts and surveys; usually the year before model development
  - *social and economic parameters* of the country – to correlate with trip patters and eventually model future transport demand
- If the model has an old base year, it needs to be *demonstrated* that it still represents existing transport demand sufficiently well

Time interval

1.6 What *time interval* is being modelled?

1.7 Is the choice of time interval justified?

1.8 Are peak periods properly determined?

- Transport models at national levels usually work with AADT (annual average daily traffic), which covers 24 hrs
- If in the area of the project there is a significant variance of the traffic volumes, the choice of time interval must be justified
- If a peak-interval model, the explanatory note must contain a calculation for determining the interval

Time interval

1.9 How modelled flows are converted to 24-hour flows; is the conversion substantiated?

- Often traffic counts do not cover 24 hours, and typically most of the trips are made during the light part of the day
- A significant question is how to translate counted traffic figures to 24-hour traffic
- (Not an issue for AADT models.)

Eamples

Daily traffic variance

Model area

1.10 Is the modelling area defined? (detailed, wider, etc.)

- We can define three types of areas:
  - *detailed modelling area* where the supply and demand of transport services are studied with the highest possible accuracy; the project being justified needs to be in that area
  - *wider modelling area*, which is also part of the transport model, but because it is relatively distant, it is modelled with lower level of detail
  - *the rest of the world* is the territory, which does not form part of the model

Model area

1.11 Is the modelling area big enough for the investment being examined?

- The modelling area is *sufficiently big*, if the differences between the traffic on its peripheral links with project and without project are marginal
- As a rule of thumb, a national model should model the neighboring areas within 1 000 – 1 500 km

Examples

Transport zones in the wider modelling area

Transport zones

1.12 What is the number of transport zones?

1.13 Are zones sufficiently small and sufficiently detailed in the project area?

- *Transport zones* are areas with (as much as possible) homogenous properties – especially in terms of functions (housing, industry, trade, etc.) and population
- Too big transport zones can be expected to lead to inaccuracies
- Transport zones should not be too big in relation with the project being justified too (e.g. the project should not fall within a single zone)

Transport zones

1.14 Are zones homogeneous (in terms of function, population distribution, etc.)?

1.15 Does statistical data and forecasts at the level of individual zones exist?

- It is recommended that model's documentation includes summary information about the distribution of the zones in terms of area, population, jobs, etc.
- Most often the zones are assumed to be the smallest administrative units for which some social and economic information exists (i.e. municipalities)
- If some of the data is not readily available at zonal level, it needs to be clarified how it is distributed per zones
- (The *origin-destination matrix* shows the number of trips per unit of time from one transport zone to another.)

1.16 *Classes of roads* modelled and total network length?

- For a national model, a high share of the network must be modelled – motorways, high class roads, as well as other important links
- As for other networks – usually all railway lines

1.17 What *vehicle classes* are modelled?

- As a minimum the model must cover *private cars, LGV, HGV and buses*
- The classes depend mostly on the available data and the possibility to model different types of trips

Volume-delay functions

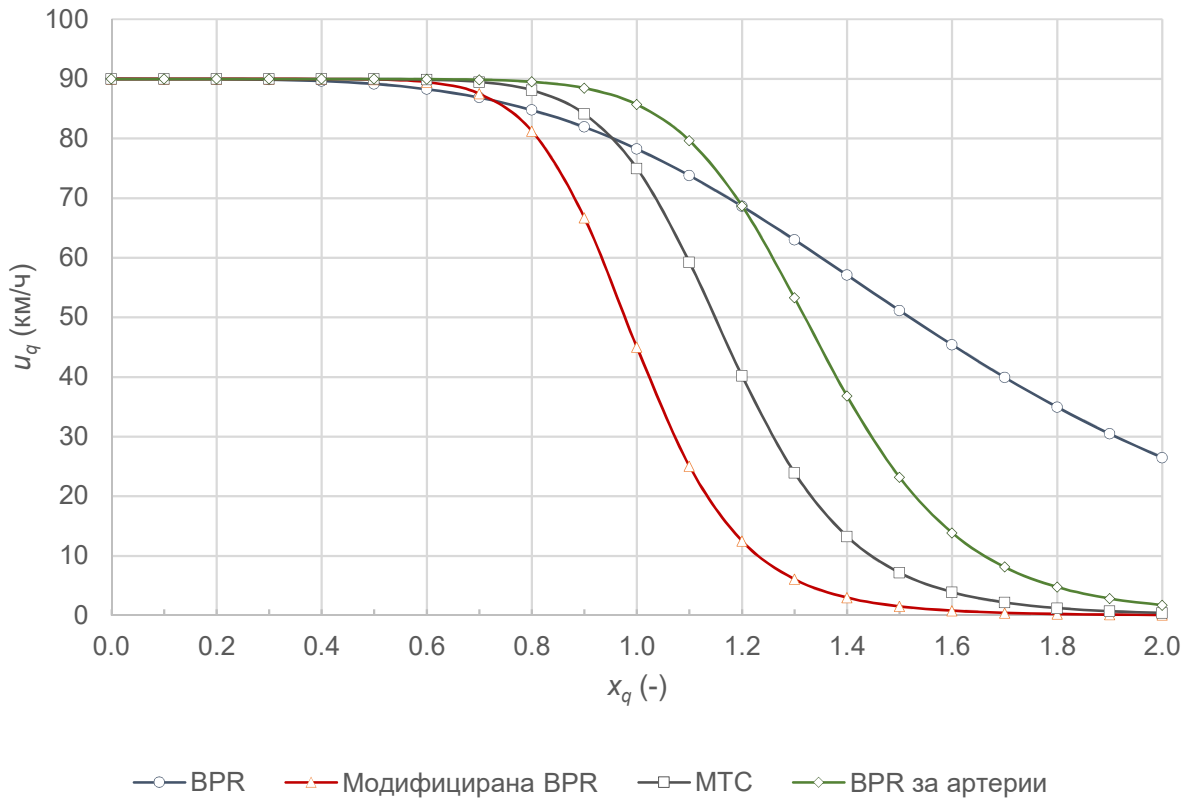
1.18 What *volume-delay function* is used and are its parameters justified?

- A appropriate volume-delay functions must be used; different functions are appropriate for different contexts

- The *parameters* of the function must be justified, namely:
  - assumed capacity of the links
  - function's coefficients
  - assumed free-flow speed of the links (next slide)

Examples

Volume-delay functions with different parameters



1.19 What *free-flow speeds* are used?

- *Free-flow speed* is the average speed of vehicles through a facility without or with moderate traffic (i.e. without interactions between cars)
- Regardless of the type of function and its parameters, a fundamental role is played by the free-flow speed
- The free-flow speed ≠ the posted speed limit
- Nowadays, a convenient way to determine free-flow speeds is Google Maps
- The speeds should be determined *individually* (i.e. per link) for at least:
  - motorways and high class roads
  - roads in the vicinity of the project

Examples

Free-flow speeds per class of road

Class	Free-flow speed
Motorway	110 km/h
I class	79 km/h
II class	70 km/h
III class	55 km/h

Source: General transport masterplan of Bulgaria (2008)

2.1 Classification or regression trip generation model?

- *Regression models* predict the number of trips as a function of variables such as:

  population, jobs, GDP, car ownership, income, industrial areas, commercial areas, students, hotel beds…

- *Classification models* predict the number of trips based on fixed trip rates per population segments and/or trip purposes

Examples

Regression model for generated trips (municipality)

$$CarTrips = -1{,}34 + 0{,}69 \ln GDP + 0{,}39 \ln Pop$$
$$LGV = 0{,}72 + 0{,}78 \ln GDP$$
$$HGV = 1{,}03 + 0{,}78 \ln GDP$$

where:

- $CarTrips$, LGV and HGV are the number of trips by private car, LGV and HGV per year
- GDP is the annual GDP of the municipality in RON
- Pop is the population of the municipality

Source: National road transport model Romania (CESTRIN, 2019)

Examples

Regression model for total number of generated trips per transport zone

$$TotTrips = 27170{,}5 + 1{,}4\ GDP - 0{,}05\ Pop$$

where:

- $TotTrips$ is the total number of trips per year
- GDP is the GDP of the transport zone in BGN
- Pop is the population of the transport zone

Source: National transport model of Bulgaria (Struma Motorway FS, 2013)

Examples

Classification model

Група	Дейност	HW	WH	TH	HT	OH	HO	HS
1	работещ	0,875	0,684	0,165	0,040	0,077	0,036	0,014
2	работещ пенсионер	0,848	0,683	0,165	0,030	0,074	0,048	0,004
3	безработен	0,042	0,024	0,466	0,363	0,208	0,239	0,037
4	ученик	0,015	0,010	0,210	0,072	0,200	0,085	0,923
5	пенсионер	0,011	0,010	0,535	0,474	0,212	0,247	0,006
6	домакиня	0,032	0,032	0,315	0,258	0,161	0,129	0,032
7	студент	0,027	0,015	0,236	0,076	0,256	0,071	0,007
	средно-претеглено:	0,501	0,392	0,266	0,151	0,137	0,098	0,085

... и т.н.

H = дом, W = работа, T = търговия, S = училище, O = друго

Source: Transport modelling 101, Practical guide (2017)

Demand model

2.2 What trip purposes (or activity pairs) are used?

- It needs to be clarified what trip purposes are being modelled and what share of the total trips they represent

2.3 What data and surveys are used to support the generation model?

- The sources of social, economic and other *data and forecasts* must be specified

2.4 Are *vehicle occupancy rates* reliably determined and forecasted?

- The model is very sensitive to occupancy rates and these need to be justified

2.5 What *mode choice model* is used?

- The *mode choice model* predicts the share of trips with different modes, depending on the preferences of the population
- Usually Logit is used
- Logit can either be estimated using surveys (preferably), or to be specified using *generalized costs*
- For the justification of road projects, it is acceptable to use static modal split

2.6 How close is the predicted modal split to the observed?

- It must be demonstrated that the modal split predicted for the base year is close to the actually observed modal split

Base year calibration

3.1 How close the model is to observed volumes without calibration?

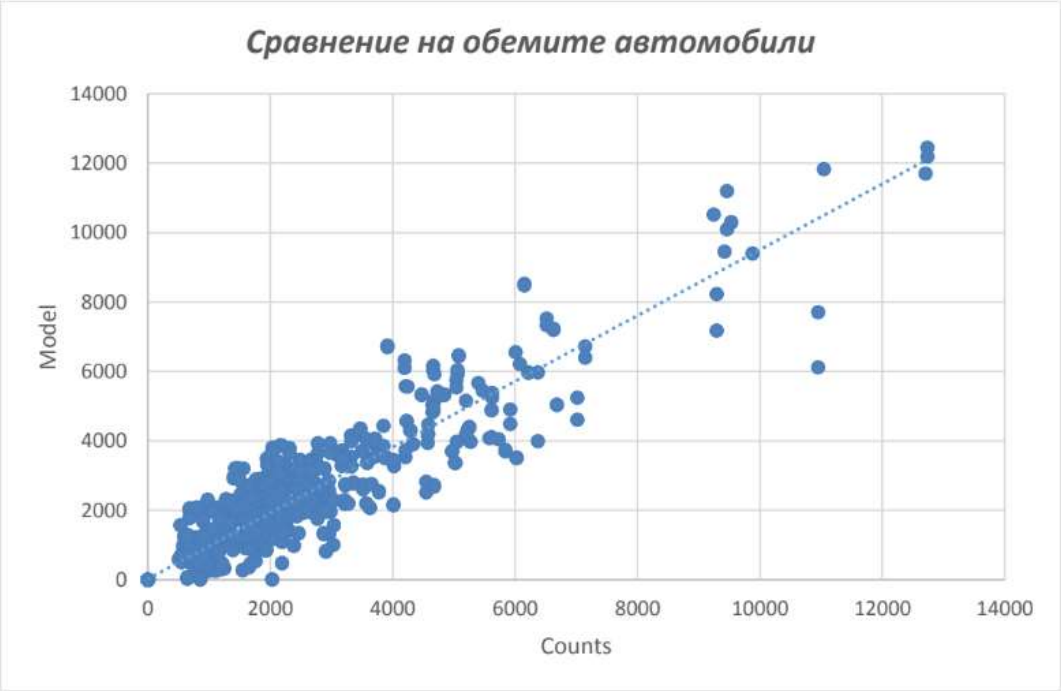
3.2 Has calibration of origin-destination matrices been carried out and how?

- In reality, the base year model never complies with strict validation requirements, *without* additional calibration of the origin-destination matrices

- *Origin-destination matrix calibration* is the process of adjusting the trips in the matrix, so that the predicted traffic flows become as close as possible to the observed flows

Examples

A reasonably well calibrated model



Фигура 2-46 Сравнение на обемите автомобили по магистралите, основните пътища и първокласните пътища

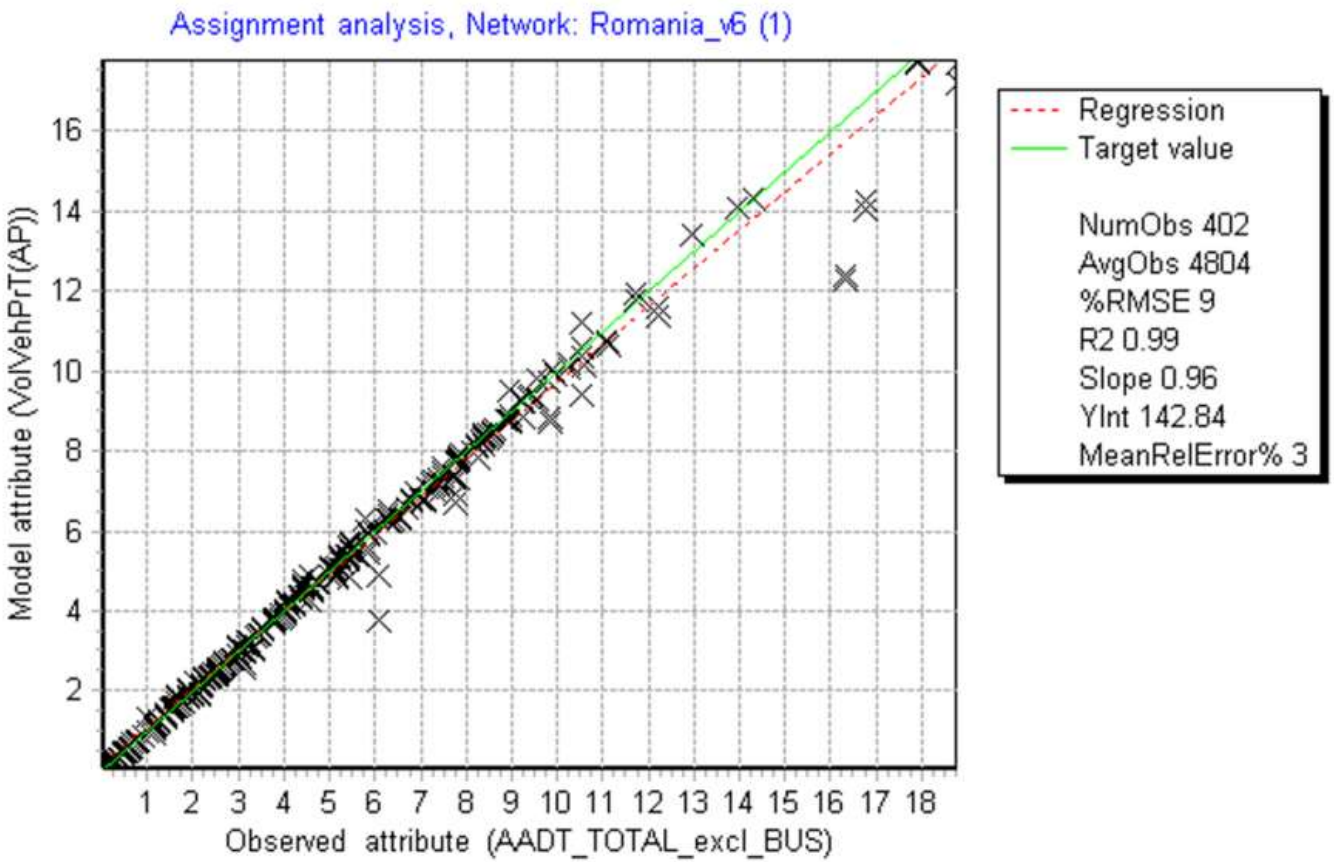
Постига се корелация от R2 = 0,91 и 64 процента от всички местоположения на преброяване имат GEH <5.

Това се счита за много добра корелация, доказваща валидността на резултатите от прикрепването.

Source: National multimodal transport model of Bulgaria (MTITC, 2017)

Examples

A very well calibrated model



Source: National road transport model of Romania (CESTRIN, 2019)

Validation of traffic volumes

4.1 How close the model is to observed volumes after calibration?

4.2 What data is used for validation and is it independent from the data used for calibration (e.g. additional counts or from an earlier year)?

- *Validation* is the process of comparing parameters predicted by the model (volumes, trip times) with observed data, which has *not been used* for calibration
- The independence of the data for calibration and validation is a requirement of major importance

4.3 Does the model comply with reasonable precision criteria?

- Such criteria are included in, e.g.:
  - JASPERS Appraisal Guidance (Transport): The Use of Transport Models in Transport Planning and Project Appraisal, 2014
  - TAG Unit M3.1 Highway Assignment Modelling, 2014. Department for Transport, UK
  - Model Validation and Reasonableness Checking Manual, 2010. Prepared for Travel Model Improvement Program, Federal Highway Administration

Examples

Validation criteria

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

M is the modelled hourly traffic
C is the counted hourly traffic

Criteria and Measures		Acceptability
Comparison of Assigned Demand		
1	Individual vehicle, passenger or freight demand within 15% of observed counts.	More than 85% of cases
2	Total screen line flows to be within 5% of observed counts.	
3	GEH statistic: (ii) individual flows : GEH < 5 (ii) screenline totals : GEH < 4	More than 85% of cases
Comparison of Journey Times		
4	Times within 15% or 1 minute if higher.	More than 85% of cases

Source: JASPERS Appraisal Guidance (Transport): The Use of Transport Models in Transport Planning and Project Appraisal (2014)

Trip time validation

4.4 Has speed/trip time been validated and how?

4.5 Does the model comply with reasonable precision criteria?

- Trip times are very important for determining the economic benefits of timesavings
- They can be validated using:
  - Google Maps
  - own floating car measurements with GPS
- It is recommended that the length of the sections for validation is between 3 and 15 км!

- (Also recommended to carry out *trip length validation*.)

Examples

Trip length validation

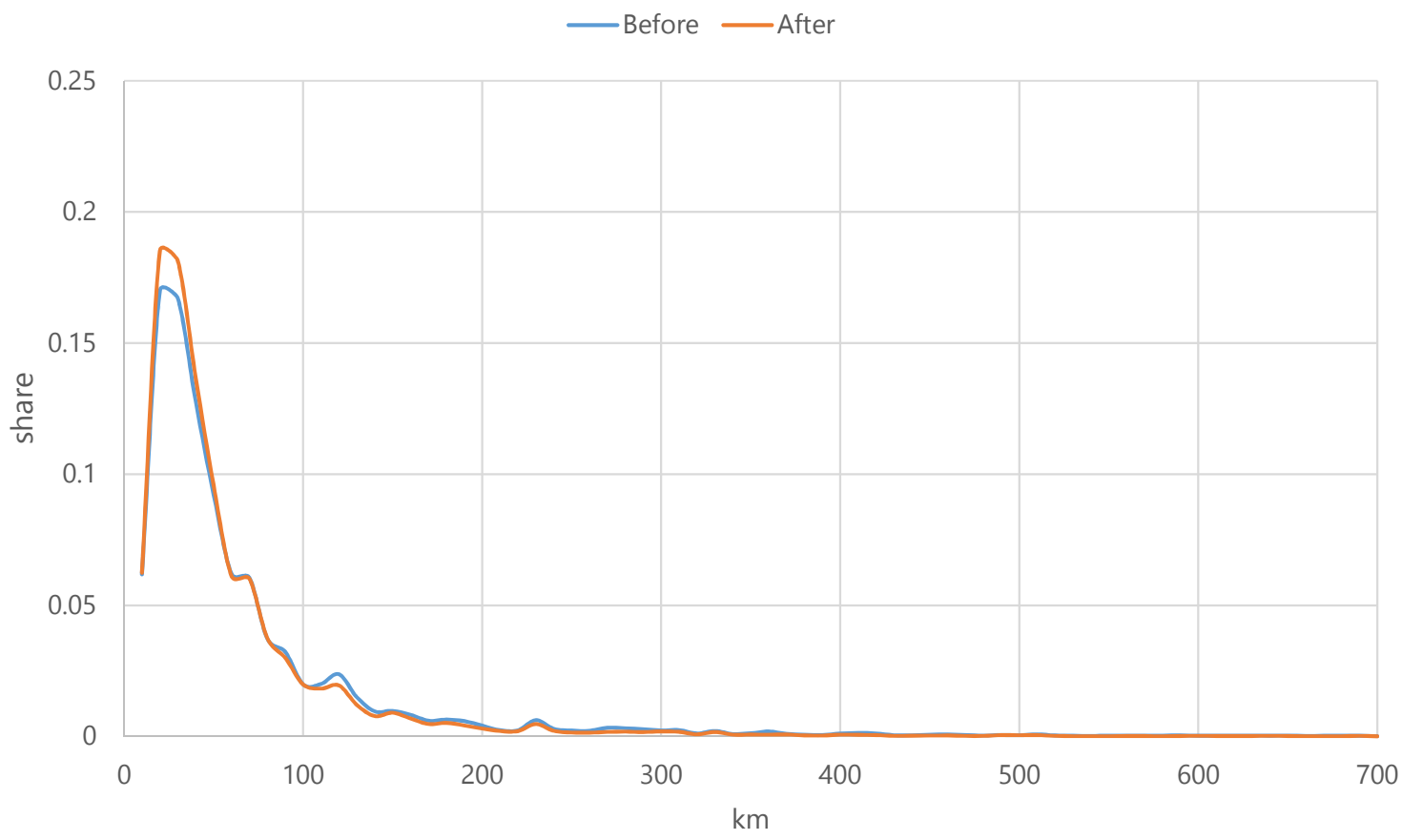
#	Relation		Trip length	Journey time (JT)				Journey speed (JS)		JT difference	JS difference
				Observed		Modeled		Observed	Modeled		
	start	end	[km]	[hh:mm]	[s]	[hh:mm]	[s]	[km/h]	[km/h]	%	%
1	Bucuresti	Brasov	184	3:00	10800	2:55	10500	61.33	63.09	2.8	-2.9
2	Brasov	Sibiu	145	2:25	8700	2:29	8940	60.00	58.39	-2.8	2.7
3	Sibiu	Deva	120	1:15	4500	1:08	4080	96.00	105.88	9.3	-10.3
4	Deva	Arad	186	2:25	8700	2:08	7680	76.97	87.19	11.7	-13.3
5	Sebes	Cluj Napoca	113	2:15	8100	2:10	7800	50.22	52.15	3.7	-3.8
6	Cluj Napoca	Oradea	155	3:00	10800	2:51	10260	51.67	54.39	5.0	-5.3
7	Bucuresti	Buzau	96	1:10	4200	1:13	4380	82.29	78.90	-4.3	4.1
8	Buzau	Focsani	76	1:00	3600	0:59	3540	76.00	77.29	1.7	-1.7
9	Focsani	Bacau	104	1:30	5400	1:20	4800	69.33	78.00	11.1	-12.5
10	Bacau	Roman	41	0:40	2400	0:36	2160	61.50	68.33	10.0	-11.1
11	Roman	Suceava	108	1:45	6300	1:35	5700	61.71	68.21	9.5	-10.5
12	Sabaoani	Iasi	74	1:10	4200	1:07	4020	63.43	66.27	4.3	-4.5
13	Bucuresti	Constanta	227	2:25	8700	2:11	7860	93.93	103.97	9.7	-10.7
14	Constanta	Tulcea	129	1:50	6600	1:47	6420	70.36	72.34	2.7	-2.8
15	Tulcea	Braila	96	1:51	6660	1:41	6060	51.89	57.03	9.0	-9.9
16	Tulcea	Galati	82	1:55	6900	1:53	6780	42.78	43.54	1.7	-1.8
17	Calarasi	Galati	158	2:20	8400	2:19	8340	67.71	68.20	0.7	-0.7

...

Source: National road transport model of Romania (CESTRIN, 2019)

Examples

Trip lengths before and after calibration



Source: National road transport model of Romania (CESTRIN, 2019)

Forecasts

5.1 Are there any forecasted volumes that look clearly unrealistic?

- The forecasted growth can be expected to be similar to historic growth

5.2 Do volumes "oscillate" from year to year?

- Significant changes of traffic flows between forecast years can be a sign of a sensitivity issue or another error

5.3 Are there any unusual diversions of flows from high-class roads to low class roads?

- Usually higher class roads have higher traffic flows; the opposite may be a network coding error

5.4 Are the results properly presented?

- The results must be presented in a form, suitable for the use in CBA
- Forecasts for the different years must be presented for “with project” and “without project” scenarios:
  - number of vehicles on the network per year
  - total passenger-km
  - total traveltimes
  - number of trips per trip purpose
  - ...

Discussion and closing remarks