Co-financed project CB 241
"Advanced traffic management on the E67 transport corridor" (SMART E67) under
INTERREG Central Baltic Sea Region Programme 2014-2020

Study on the effectiveness and on the improvements of the Central Baltic transport Project „Smart E67"

Ex-Ante and Ex-Post evaluation

Part II

2019

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Study on the effectiveness and on the improvements of the Central Baltic transport Project „Smart E67“ Ex-Ante and Ex-Post evaluation, Part II

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FOREWORD

SMART E67 project aims to increase the efficiency and safety of passenger and cargo mobility in the Central Baltic region. The project introduced elements of Intelligent Transport System (ITS) adding information and communication technology to E67 transport corridor – a key transport corridor in Estonia and Latvia (North-South direction) covering 202 km in Latvia and 192 km in Estonia.

The overall objective of this study is to evaluate the project "Smart E67" performance results, to measure the before situation and to investigate possible changes after implementation of new technological ITS measures. The list of performance results includes travel time savings, accidents cost savings from improved traffic safety and reduction of vehicle emissions.

The specific objectives of this study are:

- to carry out an Ex-Ante and Ex-Post evaluation of the project Smart E67 actions;
- to find the main impacts of its deliverables to traffic efficiency, road safety and vehicle emission;
- to find suitable methodological approach to carry out abovementioned evaluations, based on existing data delivered by the Client or reachable from open data sources.

Introduction of ITS equipment to E67 Via Baltica route has had an expected impact to total travel time of passengers and cargos by reducing it 0,57% compared to the previous situation. Installation of ITS equipment is also expected to improve traffic safety since road users are more operatively and accurately informed about the road and pavement condition. However, the change in the situation with regard to road safety is estimated. Longer-term monitoring of the situation on Via Baltica route sections is needed to obtain data on actual changes in road safety.

CONTENTS

1. INTRODUCTION

The study on the effectiveness and on the improvement of the Central Baltic transport project „Smart 67" is divided into two parts – Ex-Ante evaluation was carried out in summer 2016 and Ex-Post evaluation has been carried out in spring/summer 2019 after all new ITS applications are in use and effective.

Suitable analysis methodology for both Ex-Ante and Ex-Post evaluation was presented and agreed before Ex-Ante evaluation in 2016. Information about traffic volume, direction and classification was available from the Client and has been updated during Ex-Post analysis.

For Ex-Post analysis Waze users time and speed data was not available. In order to attain detailed knowledge of the examined subject, the Consultant made two in-site car trips in full length of the project area on road E67 in May and June 2019.

Information about Estonian traffic accidents data is gathered from the Estonian Road Administration and Latvian traffic accidents from the Client. Traffic accident data has been updated during the Ex-Post evaluation.

2. ITS DEVICES

2.1. Road and ITS devices locations

The list of installed ITS devices and other settings made for existing devices are presented in the Table 2.1.

Table 2.1. Location and description of the installed ITS device on the E67 Via Baltica route

No	State	Road no	Km	SEC	Location	Device	Installation date	Start of work date
1	EST	4	13.90	EST_1	Laagri	VSL_large		09/2018
2	EST	4	13.90	EST_1	Laagri	VSL_large		09/2018
3	EST	4	14.25	EST_1	Laagri	VMS info_large		09/2018
4	EST	4	14.59	EST_1	Jälgimäe	VSL_large		09/2018
5	EST	4	14.59	EST_1	Jälgimäe	VSL_large		09/2018
6	EST	4	15.03	EST_1	Topi	VSL_large		09/2018
7	EST	4	15.03	EST_1	Topi	VSL_large		09/2018
8	EST	4	15.34	EST_1	Topi	VWS and VSL_large		09/2018
9	EST	4	15.34	EST_1	Topi	VWS and VSL_large		09/2018
10	EST	4	17.85	EST_1	Kanama	VSL_large		09/2018
11	EST	4	17.85	EST_1	Kanama	VSL_large		09/2018
12	EST	4	18.98	EST_1	Kanama	VSL_large		09/2018
13	EST	4	18.98	EST_1	Kanama	VSL_large		09/2018
14	EST	4	19.14	EST_1	Kanama	VMS info_large		09/2018
15	EST	4	19.48	EST_1	Kanama	VMS info_large		09/2018
16	EST	4	19.56	EST_1	Rahula	VSL_large		09/2018
17	EST	4	19.56	EST_1	Rahula	VSL_large		09/2018
18	EST	4	20.00	EST_1	Rahula	VWS and VSL_large		09/2018
19	EST	4	20.00	EST_1	Rahula	VWS and VSL_large		09/2018
20	EST	4	23.04	EST_1	Jõgisoo	VSL_large		09/2018
21	EST	4	23.39	EST_1	Jõgisoo	VSL_large		09/2018
22	EST	4	23.39	EST_1	Jõgisoo	VSL_large		09/2018
23	EST	4	24.26	EST_1	Jõgisoo	VSL_large		09/2018
24	EST	4	24.26	EST_1	Jõgisoo	VSL_large		09/2018
25	EST	4	24.55	EST_1	Jõgisoo	VSL_large		09/2018
26	EST	4	27.02	EST_1	Ääsmäe	VWS and VSL_large		09/2018
27	EST	4	27.02	EST_1	Ääsmäe	VWS and VSL_large		09/2018
28	EST	4	27.02	EST_1	Ääsmäe	VWS and VSL_small		09/2018
29	EST	4	28.43	EST_2	Ääsmäe	VWS and VSL_small		09/2018
30	EST	4	64.06	EST_2	Märjamaa	VMS info_small		09/2018
31	EST	4	64.10	EST_2	Märjamaa	VMS info_small		09/2018
32	EST	4	123.88	EST_5	Sauga	VMS info_small		12/2018
33	EST	4	125.20 – 133.00	EST_5	Pärnu city bypass	Readjustment of existing traffic lights to adaptive regime		12/2018
34	EST	4	130.45	EST_5	Papiniidu sild	VWS and VSL_small		12/2018
35	EST	4	130.45	EST_5	Papiniidu sild	VWS and VSL_small		12/2018
36	EST	4	131.00	EST_5	Papiniidu sild	VWS and VSL_small		12/2018
37	EST	4	131.00	EST_5	Papiniidu sild	VWS and VSL_small		12/2018
38	EST	4	139.88	EST_5	Raeküla	VMS info_small		12/2018
39	EST	4	191.79	EST_6	Ikla	VMS info_small		12/2018
40	LAT	A1	4.03	LAT_14	Baltezers	Readjustment of existing traffic lights to adaptive regime	28.09.2018	28.09.2018

No	State	Road no	Km	SEC	Location	Device	Installation date	Start of work date
41	LAT	A1	10.4-12.35	LAT_13	Ādaži	New RWS, Fixed matrix type alarming VMS, Fixed matrix type speed limit VMS	20.09.2018	27.11.2018
42	LAT	A1	13.5	LAT_13	Gaujas tilts	Incident monitoring	13.09.2018	13.09.2018
43	LAT	A1	21.7	LAT_12	Lilaste	RWS improvement, Fixed matrix type alarming VMS	11.10.2018	27.11.2018
44	LAT	A1	39.2	LAT_12	Skulte	RWS improvement, Fixed matrix type alarming VMS	4.10.2018	27.11.2018
45	LAT	A1	45.6	LAT_12	Dunte	RWS improvement, Fixed matrix type alarming VMS	11.09.2018	27.11.2018
46	LAT	A1	57.55	LAT_11	Tūja	New RWS, Freely programmed VMS, Fixed matrix type alarming VMS	02.10.2018	27.11.2018
47	LAT	A1	72.3	LAT_11	Vitrupe	RWS improvement, Fixed matrix type alarming VMS	13.09.2018	27.11.2018
48	LAT	A1	97.8	LAT_9	Ainaži	New RWS, Fixed matrix type alarming VMS	18.09.2018	27.11.2018
49	LAT	A4	2.88	LAT_15	A4/Upesciema iela (Berģi)	Readjustment of existing traffic lights to adaptive regime	28.09.2018	28.09.2018
50	LAT	A4	4.86	LAT_15	P2 (Juglas papīrfabrika)/A4	Readjustment of existing traffic lights to adaptive regime	25.09.2018	28.09.2018
51	LAT	A4	7.6	LAT_16	Mucenieki	New RWS, Fixed matrix type alarming VMS	08.10.2018	27.11.2018
52	LAT	A4	9.35	LAT_16	A4/P4 (Ērgļu ceļš)	Readjustment of existing traffic lights to adaptive regime	27.09.2018	28.09.2018
53	LAT	A4	14.29	LAT_17	A4/P5 (Ogres ceļš)	Readjustment of existing traffic lights to adaptive regime	18.09.2018	18.09.2018
54	LAT	A4	14.29	LAT_17	A4/P5 (Ogres ceļš)	Incident monitoring	13.09.2018	13.09.2018
55	LAT	A6	19.13	LAT_18	A6/Rīgas iela (Salaspils)	Readjustment of existing traffic lights to adaptive regime	15.10.2018	15.10.2018
56	LAT	A6	18.85	LAT_18	A6/Enerģētiķu iela (Salaspils)	Readjustment of existing traffic lights to adaptive regime	15.10.2018	15.10.2018
57	LAT	A7	19.53	LAT_22	Ķekava	RWS improvement, Fixed matrix type alarming VMS	24.09.2018	27.11.2018
58	LAT	A7	32.9	LAT_22	Bērziņi	RWS improvement, Fixed matrix type alarming VMS	25.09.2018	27.11.2018
59	LAT	A7	43.83	LAT_22	A7/Skolas iela (Iecava)	Readjustment of existing traffic lights to adaptive regime	15.10.2018	15.10.2018
60	LAT	A7	44.09	LAT_22	A7/Ed.Virzas iela (Iecava)	Readjustment of existing traffic lights to adaptive regime	15.10.2018	15.10.2018
61	LAT	A7	52.9	LAT_23	Zariņi	RWS improvement, Fixed matrix type alarming VMS	26.09.2018	27.11.2018
62	LAT	A7	71.4	LAT_25	Ceraukste	New RWS, Fixed matrix type alarming VMS	10.10.2018	27.11.2018
63	LAT	A7	82.5	LAT_25	Grenctāle	RWS improvement, Fixed matrix type alarming VMS	27.09.2018	27.11.2018

2.2. Investment cost

Important part of the analysis is investment cost of the installed ITS devices, including installation, maintenance and operating costs. On the E67 Via Baltica route installed ITS device costs are presented in Table 2.2.

Table 2.2. Investment costs of the installed ITS device on the E67 Via Baltica route

No	State	Road no	SEC	SEC length, km	Investment cost, no VAT, EUR	Investment cost, incl. VAT, EUR	Investment cost, no VAT, EUR/km	Investment cost, incl. VAT, EUR/km
1	EST	4	EST_1	14.132	317 358	380 830	22 457	26 948
2	EST	4	EST_2	36.994	63 568	76 282	1 718	2 062
3	EST	4	EST_5	18.733	176 660	211 992	9 430	11 316
4	EST	4	EST_6	50.401	22 643	27 172	449	539
5	LAT	A1	LAT_9	11.837	50 000	60 000	4 224	5 069
6	LAT	A1	LAT_11	30.629	119 167	143 000	3 891	4 669
7	LAT	A1	LAT_12	35.771	130 000	156 000	3 634	4 361
8	LAT	A1	LAT_13	14.36	97 500	117 000	6 790	8 148
9	LAT	A1	LAT_14	6.94	15 000	18 000	2 161	2 594
10	LAT	A4	LAT_15	4.875	35 833	43 000	7 350	8 821
11	LAT	A4	LAT_16	4.48	74 167	89 000	16 555	19 866
12	LAT	A4	LAT_17	11.095	11 667	14 000	1 052	1 262
13	LAT	A6	LAT_18	5.587	16 667	20 000	2 983	3 580
14	LAT	A7	LAT_22	25.173	106 667	128 000	4 237	5 085
15	LAT	A7	LAT_23	20.955	41 667	50 000	1 988	2 386
16	LAT	A7	LAT_25	16.494	91 667	110 000	5 558	6 669
TOTAL				**308.456**	**1 370 229**	**1 644 275**	**4 442**	**5 331**
Annual maintenance costs, EUR					**34 256**	**41 107**	**111**	**133**

Annual maintenance and operating costs of the ITS devices installed on the E67 Via Baltica route are estimated to be approximately 2.5% of the total purchase and installation cost.

3. TRAFFIC VOLUME

3.1. Traffic volume on E67 Via Baltica route

3.1.1. Traffic volume on E67 route Estonian sections

The average change in traffic volume over the last decade on the E67 Via Baltica route's Estonian section (road no 4 Tallinn-Pärnu-Ikla) can be found on Charts 3.1 and 3.2. Traffic volume has been continuing to increase also during 2016-2018. The volume of articulated trucks traffic has increased over 85% compared to the year 2005.

Abbreviations shown on the chart:

- AADT – annual average daily traffic;
- SAPA – light vehicles: passenger cars and vans (vehicle length < 6 m);
- VAAB –buses, light and medium trucks (vehicle length 6-12 m);
- AR – heavy trucks, articulated trucks (vehicle length > 12 m).

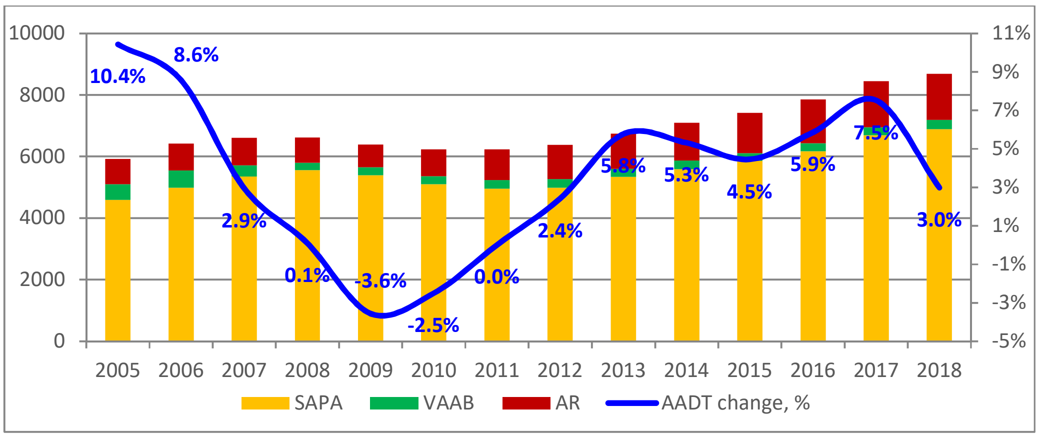

Chart 3.1. Traffic volume trend on E67 Via Baltica Estonian sections 2005-2018

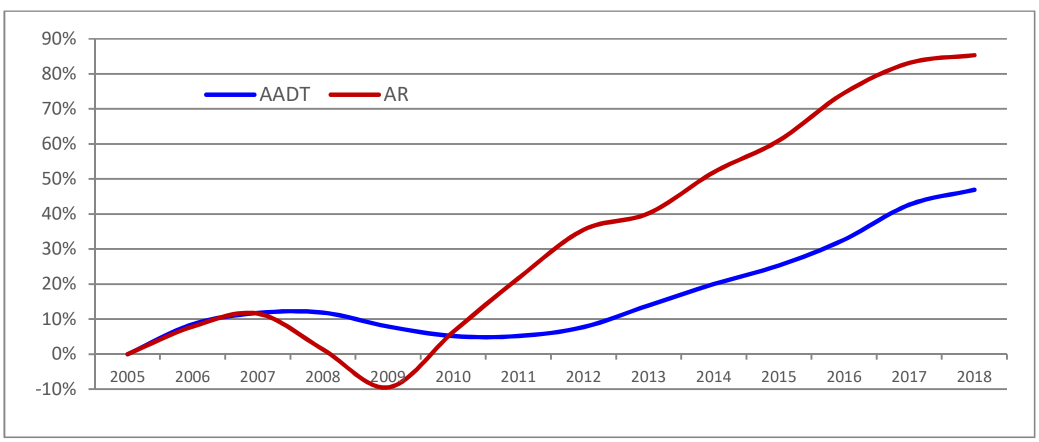

Chart 3.2. Annual average daily traffic and trucks volume trends 2005-2018 on E67 Via Baltica Estonian sections

Table 3.1. Annual average daily traffic 2018 in E67 Via Baltica route Estonian sections

Road no	Start km	End km	Length, km	E67	Traffic volume 2018, veh/day				Traffic volume change 2018/2015, %	
				section	AADT	SAPA	VAAB	AR	AADT	AR
4	0.0	13.0	13.0	EST_0	Tallinn city section					
4	13.0	13.7	0.6	EST_1	32723	31228	939	556	4%	-16%
4	13.7	14.8	1.1	EST_1	29450	27893	892	665	8%	11%
4	14.8	18.3	3.5	EST_1	21078	20196	506	376	5%	-9%
4	18.3	27.6	9.3	EST_1	16705	14480	542	1683	10%	9%
4	27.6	39.2	11.6	EST_2	8911	7251	280	1380	15%	20%
4	39.2	50.1	10.8	EST_2	8599	6903	275	1421	14%	32%
4	50.1	64.2	14.1	EST_2	8423	6574	326	1523	14%	13%
4	64.2	68.5	4.3	EST_3	8143	6430	272	1441	25%	7%
4	68.5	82.6	14.1	EST_3	7290	5460	235	1595	12%	19%
4	82.6	89.6	7.0	EST_3	8103	6449	247	1407	33%	16%
4	89.6	100.7	11.1	EST_3	8299	6572	289	1438	17%	13%
4	100.7	102.7	2.0	EST_3	8273	6433	263	1577	22%	27%
4	102.7	111.4	8.7	EST_4	8897	6855	381	1661	15%	14%
4	111.4	120.7	9.3	EST_4	10139	8342	337	1460	24%	11%
4	120.7	122.7	2.0	EST_4	9747	7735	364	1648	12%	28%
4	122.7	125.2	2.5	EST_5	12969	10741	511	1717	11%	15%
4	125.2	130.9	5.7	EST_5	13764	11574	486	1704	27%	0%
4	130.9	133.4	2.5	EST_5	11026	9099	210	1717	32%	15%
4	133.4	141.4	8.0	EST_5	10828	8592	371	1865	18%	17%
4	141.4	152.4	11.0	EST_6	5666	3850	244	1572	29%	18%
4	152.4	168.3	15.8	EST_6	4653	3109	193	1351	17%	7%
4	168.3	191.8	23.5	EST_6	4591	2832	177	1582	43%	21%
4	191.8	192.3	0.5	EST_7	Ikla state border area					

3.1.2. Traffic volume on E67 route Latvian sections

The change in average traffic volume on Latvia’s E67 route sections over the last five years is shown on Charts 3.3 and 3.4. The traffic volume has increased steadily in Latvia, and the proportion of heavy trucks continues to rise. AADT data for the year 2019 is preliminary.

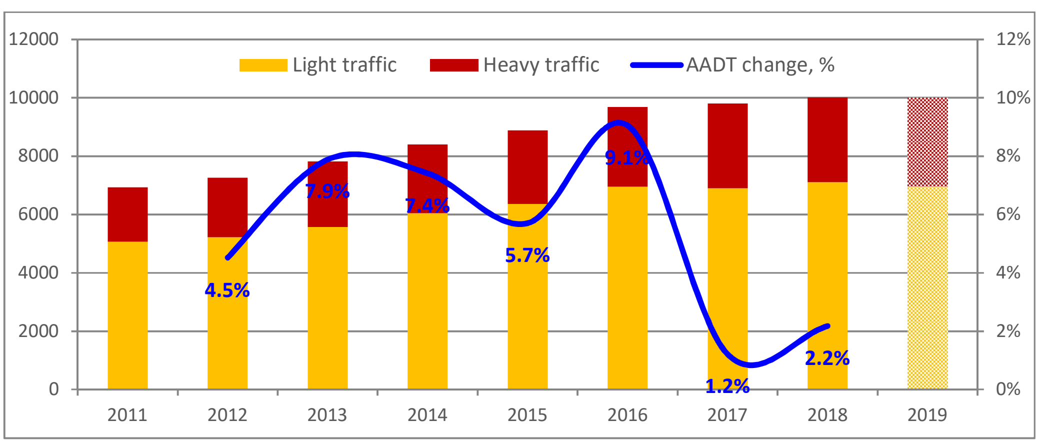

Chart 3.4. Traffic volume trend on E67 Via Baltica Latvian sections 2011-2015

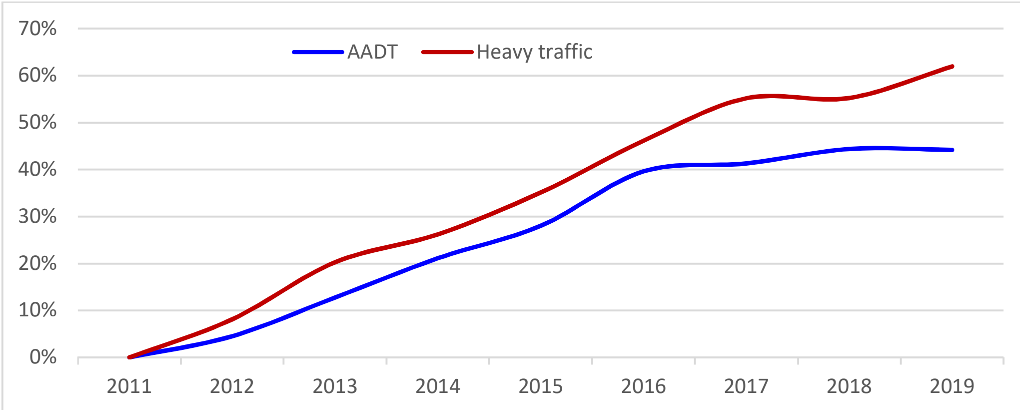

Chart 3.5. Annual average daily traffic and trucks volume trend 2011-2018 on E67 Via Baltica Latvian sections

Table 3.2. Annual average daily traffic in E67 Via Baltica route Latvian sections

Road no	Start km	End km	Length, km	E67 section	Traffic volume 2018, veh/day		Change 2018/2015, %	
					AADT	Heavy trucks	AADT	Heavy trucks
A1	83.9	101.7	17.9	LAT_9-11	4573	1966	2%	-2%
	57.1	83.9	26.8	LAT_11	5555	2444	26%	35%
	40.4	57.1	16.7	LAT_12	6670	2268	15%	18%
	31.6	40.4	8.8	LAT_12	8097	2348	17%	17%
	21.3	31.6	10.3	LAT_12	9404	2351	13%	28%
	13	21.3	8.3	LAT_13	13035	2607	5%	11%
	6.9	13	6.1	LAT_13	14802	2812	15%	55%
	0.0	6.9	6.9	LAT_14	26856	3760	15%	-5%
A4	0.0	4.9	4.9	LAT_15	15475	4075	11%	17%
	4.9	9.4	4.5	LAT_16	9941	2724	12%	18%
	9.4	14.3	4.9	LAT_17	9769	2442	6%	1%
	14.3	20.5	6.2	LAT_17	8392	2620	-9%	-2%
A5	0.0	7.0	7.0	LAT_19-20	12625	3219	35%	23%
	7.0	8.6	1.6	LAT_19-20	12713	3263	14%	18%
A6	17.3	19.1	1.8	LAT_18	25618	3740	15%	11%
	19.1	23	3.8	LAT_18	22216	3999	12%	12%
A7	19.4	44.6	25.2	LAT_22	13349	3916	12%	10%
	44.6	65.4	20.8	LAT_23	10492	3357	14%	14%
	65.4	85.1	19.7	LAT_24-25	5950	3076	19%	19%

4. TRAVEL TIME

For Ex-Post analysis Waze data was not available. Therefore changes on the travel time data before and after installation of ITS devices has been defined mainly based on the In-site car trips (section EST_5 and LAT_22) and theoretical calculations (section EST_1).

4.1. Road users' travel costs

For the Ex-Post analysis time values used in the analysis has been updated according to the latest (2018) data. According to the Statistics Estonia, the average gross wage in 2018 was 1310 euros/month. The average gross wage in 2018 in Latvia was 1004 euros/month. Assuming that there are 160 work hours in one month, the hourly price in Estonia is 8,19 euros and in Latvia 6,28 euros (Chart 4.1.).

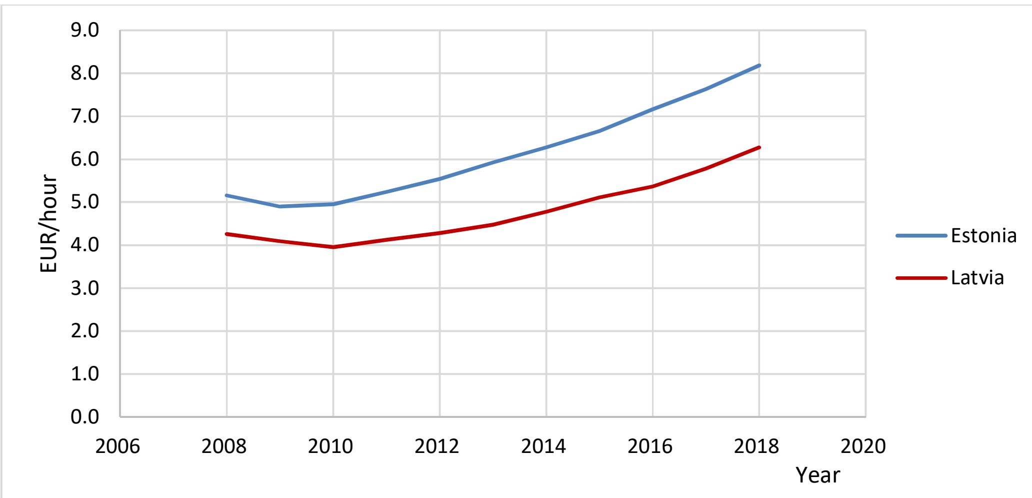

Chart 4.1. Change of average salary unit cost in Estonia and in Latvia

The updated main parameters of time spent can be found in Table 4.1.

Table 4.1. The average time values used in the analysis (2018 data)

State	The average cost value of passenger working time	The average cost value of passenger non-working time	The cost of cargo delay
Estonia	5,74 euro/h	1,64 euro/h	0,30 euro/h
Latvia	4,40 euro/h	1,26 euro/h	0,23 euro/h
Total	5,07 euro/h	1,45 euro/h	0,27 euro/h

4.2. Travel time and speed data of In-site car trips

In-site car trips for travel time surveys are made on the Via Baltica route for Ex-Post analysis on the same principle as for Ex-Ante analysis. Individual driving along the route has been done for Ex-Post analysis twice. Traffic rules and normal speed flow has been followed when driving on the route. The data has been registered and saved using GPSLogger[1] mobile phone application. Data collection frequency during the driving times has been high (1-2 seconds). That ensures accurate and precise data for analysing travel time and driving speeds.

In-site car trips were performed once in May and once in June 2019 on the E67 Via Baltica route:

- On the direction Estonia – Latvia, direction 1
  - Wednesday, 15.05.2019
  - Friday, 14.06.2019
- On the direction Latvia – Estonia, direction 2
  - Thursday, 16.05.2019
  - Sunday, 16.06.2019

Comparison of the average driving speed in the E67 Via Baltica route sections based on the In-site car trips data made on 2016 and 2019 is presented in the Chart 4.2.

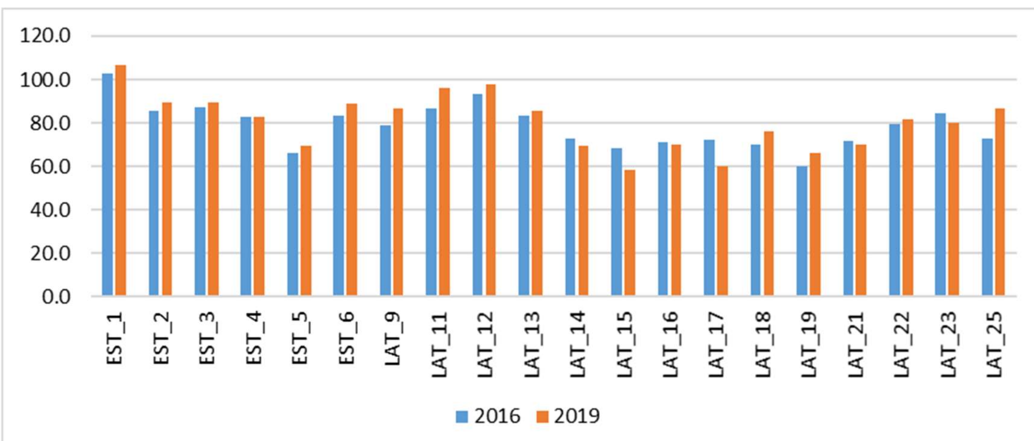

Chart 4.2. Comparison of the average driving speed in the E67 Via Baltica route sections based on the In-site car trips data made on 2016 and 2019

It is generally seen that the average speed of passing through the road sections of Estonia has increased, while in Latvia it has dropped on quite a number of road sections. However, it may be assumed that this is not related to the installation of ITS equipment or other work carried out within the framework of the Smart E67 project, but other problems are affecting. Traffic volume has already become too high for existing road cross-sections (especially on Riga bypass

[1] http://code.mendhak.com/gpslogger/

road sections) and road capacity has reached there a critical limit that can no longer be improved by small-scale work. Based on the above, in this Ex-Post analysis, the driving speed data of the Riga bypass road sections are the same before and after the installation of the ITS equipment, i.e. the impact of the installation of the ITS equipment and readjustment of the traffic lights on the driving speed of the road users is not taken into account.

The summary of the results on average driving speeds during the In-site car trip during 2016 and 2019 (before and after ITS-device installation) on the Via Baltica route can be found in Table 4.3.

Table 4.3. Average driving speed in the E67 Via Baltica route during 2016 and 2019 based on the In-site car trips data

SEC_ID	SEC name	State	SEC (in chart)	Average speed, km/h		Difference 2019 vs 2016
				2016	2019	
E67(4)_1_s1	Laagri-Ääsmäe	EST	EST_1	102.8	106.9	4.0%
E67(4)_1_s2	Ääsmäe-Märjamaa	EST	EST_2	85.4	89.6	4.9%
E67(4)_1_s3	Märjamaa-Halinga	EST	EST_3	87.5	89.7	2.6%
E67(4)_1_s4	Halinga-Jänesselja	EST	EST_4	82.8	82.6	-0.2%
E67(4)_1_s5	Jänesselja-Uulu	EST	EST_5	66.4	69.4	4.5%
E67(4)_1_s6	Uulu-Ikla (Border area)	EST	EST_6	83.4	89.1	6.9%
EST Total				**84.4**	**88.0**	**4.3%**
E67(A1)_2_s9	Ainaži (Border area)-Salacgriva city border	LAT	LAT_9	79.0	86.7	9.8%
E67(A1)_2_s11	Salacgriva city border-Jelgavkrasti (P11)	LAT	LAT_11	86.6	96.1	11.0%
E67(A1)_2_s12	Jelgavkrasti (P11)-Lilaste (V101)	LAT	LAT_12	93.3	97.7	4.8%
E67(A1)_2_s13	Lilaste (V101)-Adaži	LAT	LAT_13	83.4	85.6	2.7%
E67(A1)_2_s14	Adaži-Ryga bypass (A4)	LAT	LAT_14	73.1	69.6	-4.7%
E67(A4)_1_s15	Ryga bypass (A4)-Amatnieki (P2)	LAT	LAT_15	68.5	59.6	-12.9%
E67(A4)_1_s16	Amatnieki (P2)-Ulupij (P4)	LAT	LAT_16	71.2	69.8	-2.0%
E67(A4)_1_s17	Ulupij (P4)-Saulkalne (A6)	LAT	LAT_17	72.3	69.7	-3.7%
E67(A6)_2_s18	Saulkalne (A4)-Salaspils (A5)	LAT	LAT_18	69.9	75.9	8.7%
E67(A5)_1_s19	Salaspils (A6)-Hydropower plant	LAT	LAT_19	60.2	66.3	10.1%
E67(A5)_1_s21	Hydropower plant-Kekava (A7)	LAT	LAT_21	71.9	69.8	-2.9%
E67(A7)_1_s22	Kekava (A5)-Iecava (P93)	LAT	LAT_22	79.7	81.8	2.7%
E67(A7)_1_s23	Iecava (P93)-Bauska City border	LAT	LAT_23	84.5	79.9	-5.5%
E67(A7)_1_s25	Bauska City border-LV border area	LAT	LAT_25	72.9	86.7	18.9%
LAT Total				**81.5**	**85.1**	**4.3%**
Grand Total				**82.9**	**86.4**	**4.3%**

4.3. Travel time and speed data of In-site car trips

During this project, the most important changes affecting the driving time of road users were made on three sections (EST_1, EST_5 and LAT_22). The impact of the changes on road users is discussed below, and the calculated impact on each road section is discussed separately.

Section EST_1 Laagri-Ääsmäe

During the project to the section EST_1 Laagri-Ääsmäe following ITS devices have been installed:

- VMS info (large) 3 pcs
- VSL (large) 18 pcs
- VWS and VSL (large) 6 pcs
- VWS and VSL (small) 1 pcs

Installed devices have been in active use since December 1, 2018 and they have been used to inform road users of the various problems (accidents, weather conditions, etc.) on the road section. In case of favourable weather conditions, the general speed limit (90 km/h) was also increased (110 km/h) during the winter period.

Summary of set speed limits during the period from December 1, 2018 till March 31, 2019 is following:

- Raised speed limit to 110 km/h in total on 84 days (app. 70% of the period);
- Normal wintertime speed limit 90 km/h in total 23 days (app. 20% of the period);
- Lowered speed limit to 80 km/h due to the weather etc. conditions in total 13 days (app. 10 % of the period).

Considering the actual (2018 data) traffic volume, distribution to the vehicle classes the length of the section and distribution of the actual speed limits following conclusions can be made:

- Before ITS device installation
  - The 90 km/h speed limit has been usually (average for 20 years) in force 190 days (52% of the year);
  - The 110 km/h speed limit has been usually in force 175 days (48% of the year);
  - Average calculated driving speed during winter time 90 km/h;
  - Average calculated driving speed during summer time 108,2 km/h;
  - Annual average driving speed is therefore calculated 98,7 km/h.
- After ITS device installation
  - Average calculated driving speed during winter time 101,7 km/h;
  - Average calculated driving speed during summer time 108,2 km/h;
  - Annual average driving speed is therefore calculated 104,8 km/h.

Considering the increased driving speeds, it is expected that the average time savings per vehicle will be 0,83 minutes. Based on the traffic volume of the EST_1 road section, the total annual time savings would be for road users 98 600 hours.

Section EST_5 Jänesselja-Uulu

During the project to the section EST_5 Jänesselja-Uulu following ITS devices have been installed:

- VMS info (small) 2 pcs
- VWS and VSL (small) 4 pcs

In addition to the installed ITS devices readjustment of existing traffic lights have been made for Pärnu bypass section (km 125,0-133,0). The traffic signal setup has had a great impact and passing of the road section has become much smoother than before, as seen from the In-site car trip data in Chart 4.3.

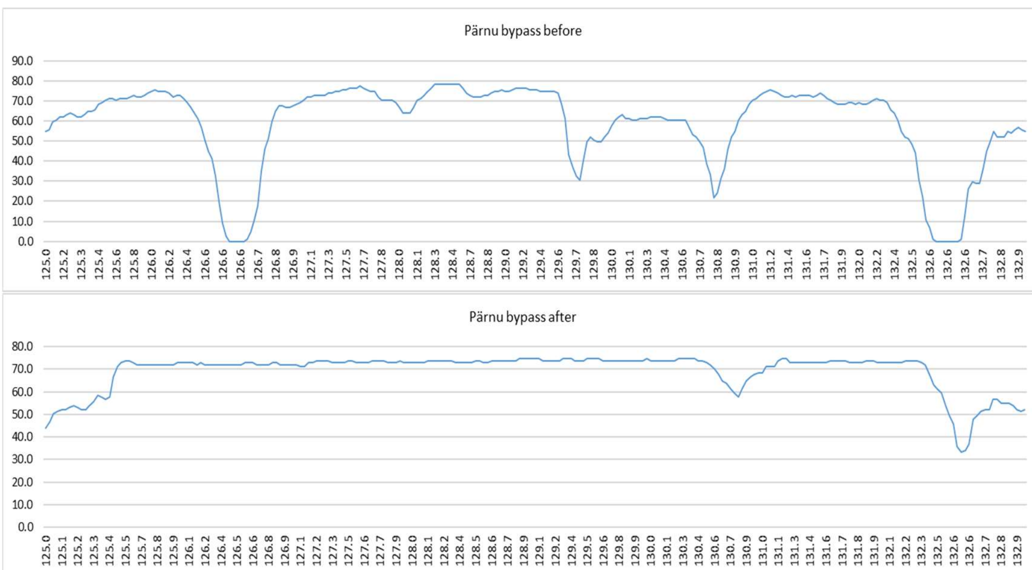

Chart 4.3. Comparison of the average driving speed in the E67 Via Baltica route Pärnu bypass before and after readjustment of existing traffic lights to adaptive regime

Average driving speed on section EST_5 has been raised from 66,4 km/h to 69,4 km/h. This means that the average passage time for the road section is reduced in total by 0,73 minutes. Based on the traffic volume of the EST_5 road section, the total annual time saving would be for road users 53 400 hours.

Section LAT_22 Kekava-Iecava

During the project to the section LAT_22 Kekava-Iecava following ITS devices have been installed and configured:

- RWS improvement;
- Fixed matrix type alarming VMS;
- Readjustment of existing traffic lights to adaptive regime in Iecava city.

Based on the In-site car trip data the average driving speed on LAT_22 section has been after ITS device installation increased from 79,7 km/h to 81,8 km/h. Considering the length of the road section (25,173 km), the driving time of one vehicle has been reduced by 0,49 minutes (0,008 hours). Based on the traffic volume of the LAT_22 road section (AADT=13349 veh/day), the total annual time saving would be for road users 40 040 hours.

Summary

As a result of the installation and configuration of the ITS equipment on these two sections, the following can be stated:

- Due to the impact of ITS equipment installation on traffic conditions (on sections EST_1, EST_5 and LAT_22), the average driving time on Via Baltica route sections has been reduced in total by 2,05 minutes/vehicle (0,034 hours/vehicle);
- According to the In-site car trips the average total driving time on Via Baltica route sections in 2016 (before ITS device installations) was 4,58 hours. Taking into account the travel time savings achieved in sections EST_1, EST_5 and LAT_22 (0,014 hour/vehicle, 0,012 hour/vehicle and 0,008 hour/vehicle respectively) after ITS device installations average total travel time has been decreased on Via Baltica route sections by 0,747%;
- Based on the traffic volume and mileage, the total annual travel time savings on route are 192 000 hours/year, which, according to the expected increase in traffic volume, is likely to increase during the coming years.

5. TRAFFIC SAFETY LEVEL

5.1. Traffic accidents

Traffic accident data on Via Baltica route has been updated for Ex-Post analysis. Updated data for years 2016-2018 is delivered by the Estonian and Latvian road authorities. Concerning Estonian data there is only fatalities and injury accidents included (damage only accidents are excluded from the analysis).

A summary on the traffic accidents as well as the number of fatalities and injuries that took place on the E67 Via Baltica route over the last years can be seen in Table 5.1.

Table 5.1. Summary of traffic accident data on E67 Via Baltica route sections

State	Section	Section name	Fatalities	Injuries	Accidents
EST	EST_1	Laagri - Ääsmäe	5	81	145
EST	EST_2	Ääsmäe - Märjamaa	8	122	115
EST	EST_3	Märjamaa - Halinga	22	130	129
EST	EST_4	Halinga - Jänesselja	9	120	124
EST	EST_5	Jänesselja - Uulu	11	60	84
EST	EST_6	Uulu - Ikla (Border area)	8	95	130
EST Total*			**63**	**608**	**727**
LAT	LAT_9	Ainazi (Border area) - Salacgriva City border	11	197	514
LAT	LAT_11	Salacgriva City border - Jelgavkrasti (P11)	17	125	344
LAT	LAT_12	Jelgavkrasti (P11) - Lilaste (V101)	10	114	299
LAT	LAT_13	Lilaste (V101) - Adazi	12	109	239
LAT	LAT_14	Adazi - Ryga bypass (A4)	11	128	259
LAT	LAT_15	Ryga bypass (A4) - Amatnieki (P2)	10	112	228
LAT	LAT_16	Amatnieki (P2) - Ulupji (P4)	15	115	203
LAT	LAT_17	Ulupji (P4) - Saulkalne (A6)	10	118	219
LAT	LAT_18	Saulkalne (A4) - Salaspils (A5)	5	113	212
LAT	LAT_19	Salaspils (A6) - Hydropower plant	6	119	227
LAT	LAT_21	Hydropower plant - Kekava (A7)	10	113	205
LAT	LAT_22	Kekava (A5) - Iecava (P93)	11	197	514
LAT	LAT_23	Iecava (P93) - Bauska City border	17	125	344
LAT	LAT_25	Bauska City border - LV border area	10	114	299
LAT Total*			**117**	**1363**	**2949**

*** REMARK – Estonian traffic accident data is for period 2006-2018 and Latvian for period 2008-2018**

Charts 5.1 and 5.2 demonstrate the changes of the annual number of accidents, injuries and fatalities over the last years (13 years in Estonia, 11 years in Latvia).

There has no significant improvement over last three years (2016-2018) comparing to previous three-year cycle (2013-2015). However it should be mentioned, that in Latvia the number of fatalities was reduced within years 2016-2017.

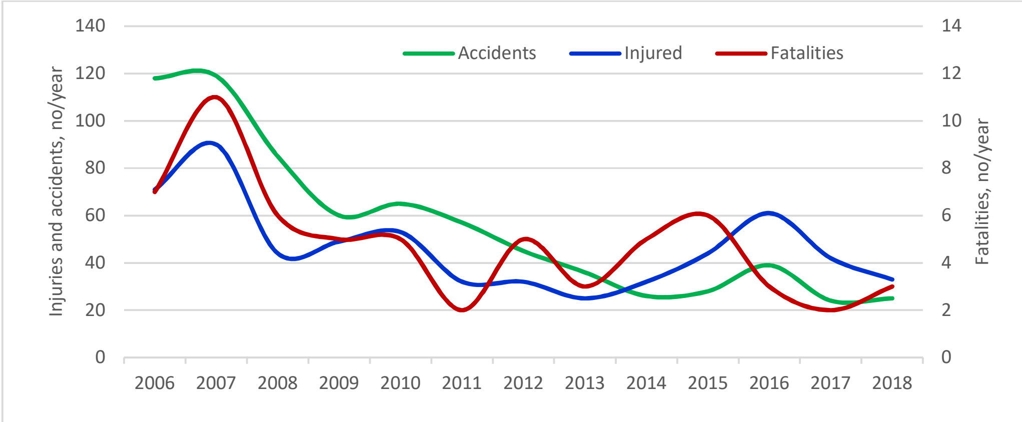

Chart 5.1. The number of fatalities, injuries and accidents on the E67 Via Baltica route Estonia sections

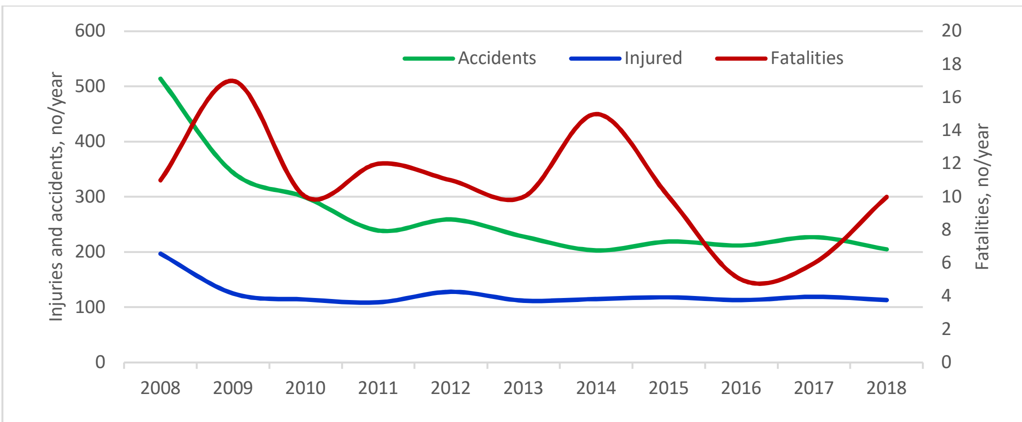

Chart 5.2. The number of fatalities, injuries and accidents on the E67 Via Baltica route Latvia sections

5.2. The impact of ITS equipment on accidents

In the current study accident rates after the ITS device installation have been estimated based on the international experiences and studies and experts estimates.

The main purpose of using variable message signs (VMS) is to alert road users to various extraordinary dangerous situations and at the same time to provide road users with feedback on their behavior.

The impact of variable message signs (VMS) on road accidents is addressed in various international studies. A detailed summary of these various studies is provided in the work[2] published in 2009 and in Table 5.2 is presented a summary of this.

[2] Elvik, R., Hoye, A., Vaa, T., Sorensen, M. The Handbook of road safety measures, second edition 2009

Tabel 5.2. Effects of variable message signs (VMS) on the number of accidents

Type of VMS-sign	Accident severity	Types of accident affected	Percentage change in the number of accidents	
			Best estimate	95% confidence interval
Accident warning signs	Injury accidents	Accidents on motorways	-44%	-59%...-22%
Fog (weather) warning signs	Unspecified severity	Accidents in fog/bad weather condition	-84%	-93%...-63%
Weather-controlled speed limits	Injury accidents	Accidents in winter Accidents in summer	-13% -2%	- -
Queue warnings on motorways	Injury accidents Property damage	Rear end collisions Rear end collisions	-16% +16%	-26%...-4% +1%...+34%
Collective feedback signs for speed	Unspecified severity	All accidents	-46%	-62%...-24%
Individual feedback signs for speed	Injury accidents	All accidents	-41%	-78%...+59%

However, the following conditions must be considered when interpreting the results of the analysis:

- These studies are already quite old to date, and intermediate technical progress has reduced the cost of VMS signs on the one hand, and on the other hand has expanded the use of these signs;
- The impact of installed ITS equipment on road safety is theoretical in this analysis and is not based on real data, as ITS equipment installed on Via Baltica route sections has been in operation for a very short time (approx. only 0.5 years).

The authors of this study are proposing a long-term monitoring of the evolution of road safety on Via Baltica route sections in order to gain a better understanding and more comprehensive overview of the impact of ITS equipment on road users, their behaviour and on traffic safety.

5.3. Accident rates

The impact of installed ITS equipment on traffic accidents and traffic safety has been taken into account only for those Via Baltica route sections where they are actually installed within the Smart E67 project. The expected reduce of the number of traffic accidents on each particular route section depends on the number of ITS devices installed and their expected impact on road safety. Based on the number of ITS devices installed during the Smart E67 project on the Via Baltica route sections, the greatest positive impact to road safety level is expected in section EST_1, where 28 different ITS devices are installed. There are quite a few road sections on Via Baltica route where no changes are expected in road safety, as these sections do not have ITS equipment installed within the project.

The surveyed E67 Via Baltica route sections' accident rate values (number per 100 million veh-km) used in the analysis before and after ITS device installations are presented in Table 5.2 and in Charts 5.3, 5.4 and 5.5.

Table 5.3. Summary of accident rate data on E67 Via Baltica route sections before and after installation of ITS devices

State	Section	Section name	Accident rate in number per 100 million veh-km					
			Before ITS installations			After ITS installations		
			Fatalities	Injuries	Accidents	Fatalities	Injuries	Accidents
EST	EST_1	Laagri - Ääsmäe	0.38	6.16	11.02	0.27	4.93	9.37
EST	EST_2	Ääsmäe - Märjamaa	0.53	8.05	7.59	0.50	7.65	7.40
EST	EST_3	Märjamaa - Halinga	1.53	9.02	8.96	1.53	9.02	8.96
EST	EST_4	Halinga - Jänesselja	1.00	13.27	13.71	1.00	13.27	13.71
EST	EST_5	Jänesselja - Uulu	1.04	5.65	7.90	0.98	5.36	7.71
EST	EST_6	Uulu - Ikla (Border area)	0.69	8.20	11.22	0.68	8.12	11.11
EST TOTAL			**1.11**	**10.72**	**12.82**	**1.06**	**10.35**	**12.53**
LAT	LAT_9	Ainazi (Border area) - Salacgriva City border	1.38	10.12	35.43	1.37	10.02	35.07
LAT	LAT_11	Salacgriva City border - Jelgavkrasti (P11)	1.46	14.78	31.33	1.45	14.64	31.01
LAT	LAT_12	Jelgavkrasti (P11) - Lilaste (V101)	1.78	16.41	36.66	1.77	16.25	36.29
LAT	LAT_13	Lilaste (V101) - Adazi	0.88	20.89	31.84	0.87	20.68	31.52
LAT	LAT_14	Adazi - Ryga bypass (A4)	1.47	17.11	37.55	1.47	17.11	37.55
LAT	LAT_15	Ryga bypass (A4) - Amatnieki (P2)	3.63	50.84	79.90	3.63	50.84	79.90
LAT	LAT_16	Amatnieki (P2) - Ulupji (P4)	1.68	28.52	52.57	1.66	28.24	52.04
LAT	LAT_17	Ulupji (P4) - Saulkalne (A6)	1.25	22.70	45.89	1.25	22.70	45.89
LAT	LAT_18	Saulkalne (A4) - Salaspils (A5)	0.38	3.64	24.88	0.38	3.64	24.88
LAT	LAT_19	Salaspils (A6) - Hydropower plant	3.28	66.50	203.60	3.28	66.50	203.60
LAT	LAT_21	Hydropower plant - Kekava (A7)	0.40	7.92	32.46	0.40	7.92	32.46
LAT	LAT_22	Kekava (A5) - Iecava (P93)	1.48	12.38	29.80	1.47	12.25	29.50
LAT	LAT_23	Iecava (P93) - Bauska City border	1.93	13.93	23.45	1.91	13.79	23.22
LAT	LAT_25	Bauska City border - LV border area	0.76	14.21	31.47	0.75	14.07	31.16
LAT TOTAL			**1.67**	**19.50**	**42.20**	**1.66**	**19.35**	**41.86**
Grand Total			**1.53**	**16.72**	**31.19**	**1.49**	**16.38**	**30.72**

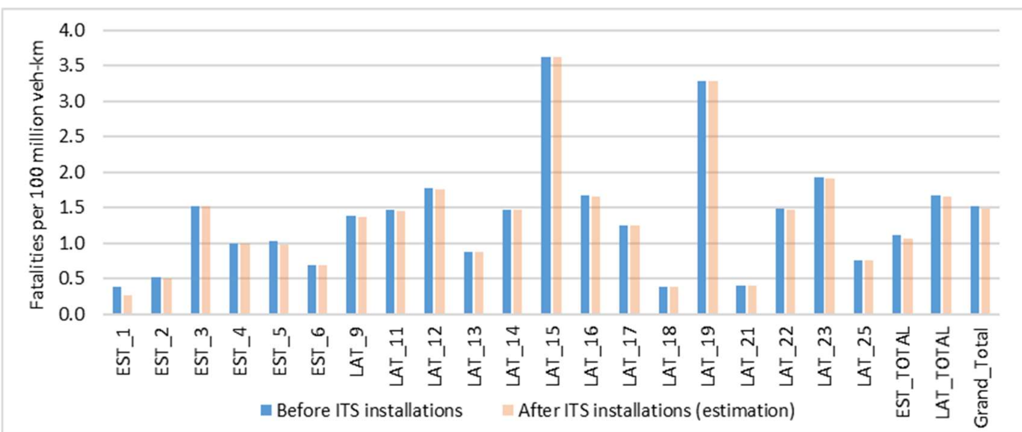

Chart 5.3. The number of fatalities per year per 100 million veh-km on E67 Via Baltica route sections

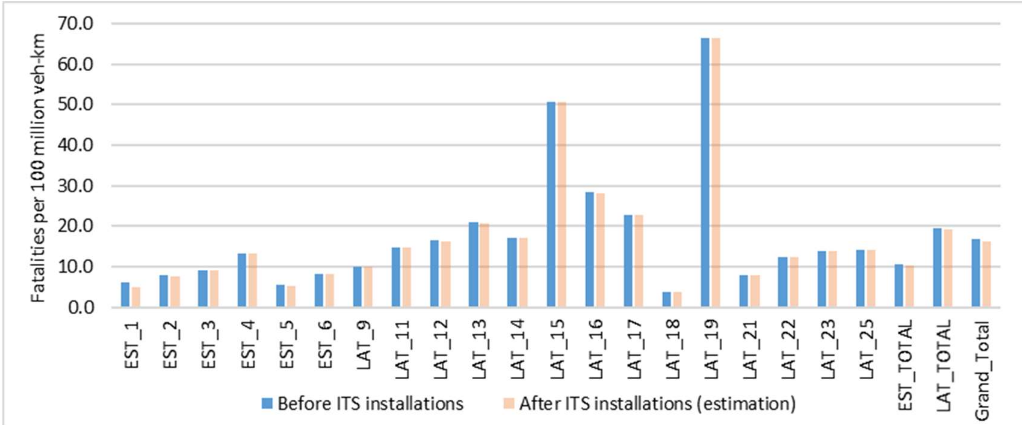

Chart 5.4. The number of injuries per year per 100 million veh-km on E67 Via Baltica route sections

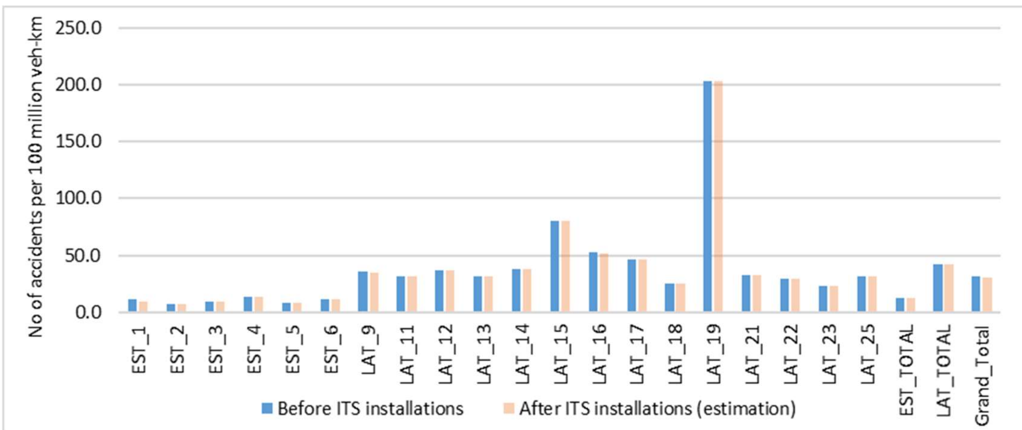

Chart 5.5. The number of accidents per year per 100 million veh-km on E67 Via Baltica route sections

6. ENVIRONMENTAL ISSUES

The amount of emissions and their content is related to the type of vehicle and their driving speed. Higher speed means more emissions and vice versa. Therefore in most cases savings in travel time mean more emissions.

Summary of the differencies of emission quantities (in tonnes and in euros) before and after ITS installations on E67 Via Baltica route sections is presented in Table 6.1.

Table 6.1. Summary of emission quantities (in tonnes and in euros) on E67 Via Baltica route sections

State	Section	Section name	Difference in emission components before and after ITS device installation in tonnes, in total for 10-year period					Difference in emission components, in EUR*
			VOC, volatile organic hydrocarbons (HC)	Nitrous oxide (NO_X)	Sulphur dioxide (SO_2)	Carbon dioxide (CO_2)	Fine particulates (PM10; PM2.5)	
EST	EST_1	Laagri - Ääsmäe	20	67	0	5 645	2	720 676
EST	EST_5	Jänesselja - Uulu	59	65	4	5 681	14	1 492 947
Grand Total during analysis period			**79**	**132**	**4**	**11 326**	**16**	**2 214 193**
Total per year			**8,9**	**14,6**	**0,5**	**1 258,4**	**1,7**	**246 021**

*** based on 2015 unit costs**

Still, there are several issues that may arise when estimating emissions and gained benefits from the investments. Current models are not yet very accurate at predicting how factors such as changes in driving cycles and congestion impacts will affect overall emissions. There are still many details that are not understood about the relationship between emissions and human health. It is unclear whether the combined effect of several pollutants is worse than the effect of a single pollutant. Other pollutants may only affect human health once their ambient concentration is above a certain threshold.

7. ANALYSIS RESULTS

The purpose of the Ex-Poste analysis is to define impact of the installed ITS devices to the E67 Via Baltica route sections. Performance indicators (road user effects, road safety effects and socio-economic and environmental effects) have been defined and included into the model for each analyzed section.

The analytical framework of the analyses is based on the concept of life cycle analysis of the made investments. Investments' (installed ITS devices) life time is estimated to be 10 years what is also analysis period. Impact of the road investments (ITS devices) are determined by comparing the total cost streams for various alternatives (installation of ITS devices) against the base case (current situation without the project or do minimum) alternative.

The starting year for all the different scenarios examined in the analysis is 2018 and the discount rate used is 4.0%[3]. The residual value of the investment at the end of the analysis period is 10%.

The cost-effectiveness criterion is to compare the amount of savings that society receives with the cost of realizing the investments made. Thus, the following conditions must be considered as criteria for a cost-benefit analysis:

- Net Present Value, NPV>0;
- Benefit/Cost Ratio, B/C ratio>1,0;
- Economical Internal Rate of Return, EIRR>4,0%.

In order to evaluate the results of the analysis, ROSEBUD WP5 (2005) proposed to use the scale for estimating the cost/benefit ratio. This scoreboard is designed to facilitate the assessment of the cost-effectiveness of road safety improvement measures. Corresponding limit values for B/C ratio are presented in the Table 7.1.

Table 7.1. Benefit/Cost Ratio ratings and corresponding limit values (ROSEBUD WP5, 2005)

Rating	Benefit/Cost Ratio (B/C-ratio)
Not acceptable	< 1,0
Acceptable	1,0…3,0
Very good	> 3,0

The results of the analysis are summarized in Table 7.2. As the results show, installing ITS devices on E67 Via Baltica route turned out to be economically justified (scenario E67 SMART base alternative) with B/C ratio in the level very good (4,2).

To determine the impact of important input parameters a sensitivity analysis was carried out for the project and following scenarios were compared:

[3] http://eur-lex.europa.eu/legal-content/ET/TXT/HTML/?uri=CELEX:32014R0480&from=ET

- Scenario 1 – expected traffic growth rate is 40% lower;
- Scenario 2 – expected benefits from reducing accident rate are 50% lower;
- Scenario 3 – Revenues from travel time savings are 50% lower.

As the results show, none of the scenarios analyzed made the project economically negative.

Table 7.2. Summary of emission quantities (in tonnes and in euros) on E67 Via Baltica route sections

No.	Scenario	Analysis period	Net present value (NPV), million. euro					
			Increase in Road Agency Costs		Benefit components			
			Investment to ITS devices	Maintenance and operation	VOC	Travel Time Costs	Reduction in Accident Costs	Emissions
1	E67 SMART base alternative	10	1.27	0.29	-0.19	2.63	6.42	-1.99
2	Sensitivity scenario 1	10	1.27	0.29	-0.21	2.47	6.04	-1.99
3	Sensitivity scenario 2	10	1.27	0.29	-0.19	2.63	3.21	-1.99
4	Sensitivity scenario 3	10	1.27	0.29	-0.19	1.31	6.42	-1.99

No.	Scenario	Analysis period	Total NPV of costs, million euro	Total NPV of benefits, million euro	Total NPV, million euro	Economical Internal Rate of Return EIRR, %	Benefit/ Cost Ratio	Benefit/ Cost rating (ROSEBUD WP5, 2005)
1	E67 SMART base alternative	10	1.56	6.87	5.31	57.2	4.4	very good
2	Sensitivity scenario 1	10	1.56	6.31	4.75	54.2	4.0	very good
3	Sensitivity scenario 2	10	1.56	3.66	2.10	27.5	2.3	acceptable
4	Sensitivity scenario 3	10	1.56	5.55	3.99	45.5	3.6	very good

8. CONCLUSIONS

With SMART E67 project it was expected to gain the decrease of total travel time of passengers and cargos by 0,57% if compared to the current travel time in E67 Via Baltica route sections in Estonia and Latvia. The project was expected to foster safety of passenger and cargo transport and diminish CO2 emissions due to time savings of transport on road. Introduction of ITS on E67 was expected to be feasible option to improve the efficiency of passenger and cargo transport in this corridor besides investment intensive infrastructure improvements.

The results and conclusions of Ex-Post analysis are as follows:

- SMART E67 project is economically feasible, with B/C ratio 4,4, which is very good according to the ROSEBUD WPS scale;
- Average driving time on the Via Baltica route sections has been reduced by 2,05 minutes/vehicle;
- Average total travel time on Via Baltica route sections has been decreased by 0,747%;
- The annual total travel time savings on Via Baltica route sections is 192 000 hours/year.

Given the final results of the Ex-Post analysis, it can be concluded that the Smart E67 project was successful and that its implementation was fully justified.