Motorway Performance in Europe and Greece

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Abstract. In terms of road safety, motorways offer much better records as compared to other road types. In EU, motorways represent an approximately 10% of all paved road network. Greece had until recently a significantly lower percentage of motorways, but during the last 15 years this percentage has been sharply increased to approach the EU average. The present paper provides a comparative analysis of motorways' safety between Greece and EU, using certain safety indicators, mainly fatality rates. The analysis is particularly concentrated in similar to Greece EU countries. Overall, Greek road safety records are traditionally poor compared to other EU countries, due to drivers' aggressive driving as the main reason. However, safety records in Greek motorways are comparable to those of EU motorways, hence the many km of newly constructed motorways in Greece have been contributed to improve country's safety indices.

Keywords: Motorways · Road safety · Safety indicators · Road fatality index

1 Introduction

Road safety in motorways is considered systematically better than in other road types. Any accident rate on motorways is lower than on main trunk or other primary highways connecting urban areas or other major trip generators. This occurs, despite the significantly higher speeds in motorways, because access to them is controlled and traffic streams are separated. Although motorways are expensive to be constructed, they do offer less travel time, comfort and travel safety. It is in favor of traffic safety to upgrade trunk roads to motorways.

In most EU member states, motorways represent a small percentage of all primary and secondary roads of the national and regional network which varies between 1% and 27% (EU15). In Greece, this figure has been at the lower limit until 2004; since then it has been sharply increased, exceeding 5%. Road safety levels have been also improved because of that.

Traffic safety levels vary widely within countries and road types, the least variation met in motorways. However, even in motorways traffic safety levels depend on their

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geometric characteristics, traffic volumes and composition, vehicles', max permitted speed as well as the country's driving culture.

The aim of this paper is to compare motorways' safety performance among EU states emphasizing on Greek motorways and how they contributed to alter safety indices in the latest years. It also attempts to interpret relevant findings and to identify some of the possible causes for that. Although several statistics are published in Greece concerning road safety, no comparisons are made with had happen in European level.

Data have been obtained by OECD (Organization for Economic Co-operation and Development), international and European transport and safety websites, Hellenic Police, Hellenic Motorways (Egnatia Odos, Attica Odos etc.), Eurostat and Greece national statistical service. Statistical data have been homogenized and analyzed to serve the objective of the paper (compare motorways' level of safety between EU and Greece).

Many safety indicators could be used, both simple and combined, concerning accident types and severity. Fatality index has been selected as the most suitable. Indicators should be deduced to road type length and/or to millions of vehicle-kilometers travelled.

2 Road Safety in Europe Versus Greece

Road safety in the EU as a whole has definitely been improving during the last years. Ambitious objectives set by the EU respective policy have not yet been exactly met but in most member states have been approached. Figure 1 presents the actual versus the targeted road fatalities set by the White Paper for EU-27 member States during the period 1990–2020, (Papaioannou et al. [1], Eurostat [2]). Between 1990 and 2020, the applied measures and policies led to a reduction by 73.5% in fatalities by road accidents. Although for the time period 2000–2010 the objectives set by the White Paper were not achieved, the difference with the actual figures was about 10%.

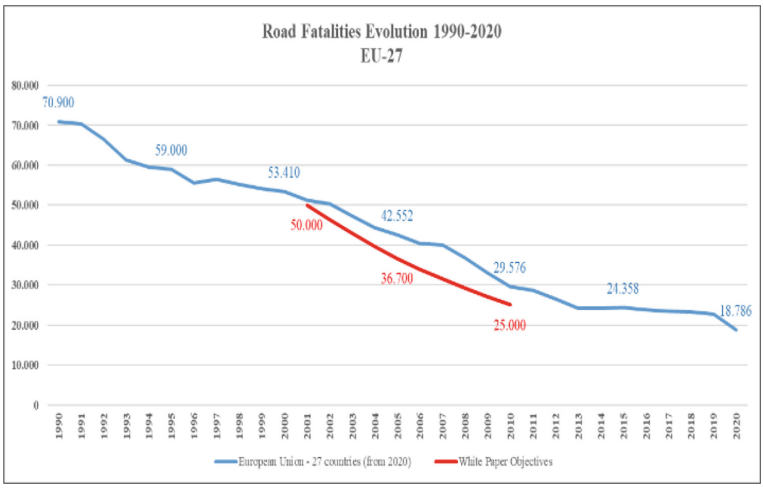


Fig. 1. A historic plot of 30-year reference EU-27 fatalities: recorded versus White Paper objectives (Own Process)

For the current decade (2020–2030) new fields will assist to improve further more levels of traffic safety, for example autonomous vehicles, artificial intelligence and vehicles' interconnection. Automotive industry has announced huge alliances and investments towards auto pilot level 5, a driver independent status of driving. There are estimations that autopilot and vehicle interconnection might decrease accident figures by as much as 90%. Since all these are still conjectures, no relevant references are available. On the other hand, the noiseless motion of electric vehicles could boost accident figures in urban areas.

Figure 2 presents the safety performance in Greece for the period 1990–2010. A gentler slope of accident reduction curve can be noticed. A worth noting peak is also detected during years 1998–2000. The peak is actually erroneous, because during that period the definition for a heavy injury road accident has been changed in Greece, as EU standards were adapted concerning both types of injuries and days of hospitalization. During 1998, a change in accident reporting and registering procedure also reduced underreporting. For a road, fatality the definition is that of a death within a 30-day period due to injuries received in the road crash. Overall, historically, accident safety performance in Greece was both worse and slower improving than in other EU countries. In an attempt to explain that slow improvement, the reference period 1990–2010 was a prosperous carefree period for the Greek society bucking against austere targets and transformations.

As above-mentioned, the length of motorways in several EU member States varies between 1% and 27%. Table 1 presents the length of motorways and all other primary and secondary rural roads in several EU member States as well as the ratio between motorways and rural roads. Greece lags in motorway length figures. However, during period 2000 – 2020, several motorways were constructed improving thus relevant figures. Figures and percentages of rural roads are fuzzy, because there are differences in the border between secondary rural roads (included) to lower-type rural roads (not included) among countries.

Table 1 presents motorways' length in EU-27 member states for the year 2019 as well their percentage over the national road network total length per country. Except from Denmark, Finland and Sweden in which the percentage is equal or higher than 1.0%, in all other countries motorways are a tiny fragment of the national road network. For these countries, it is impressive that despite the weather conditions mainly during winter, 1.0% of their national road network concern motorways. It could be assumed that the level of road safety is higher in these countries compared to others. Specifically for Greece, apart from the poor economic indices and an economic crisis lasting almost a decade, the country has a particularly ragged terrain making the construction of motorways more expensive (cost per kilometre).

Rounded figures have been generally preferred to accurate ones. It is the simplest way to reduce the 'noise' at the various indices and highlight the main trends. In addition, among the many traffic safety indices, only the one concerning the fatalities has been selected for emphasis. Generally, all safety indices provide consistent results, but that referring to fatalities is the most depressive and more readily perceived.

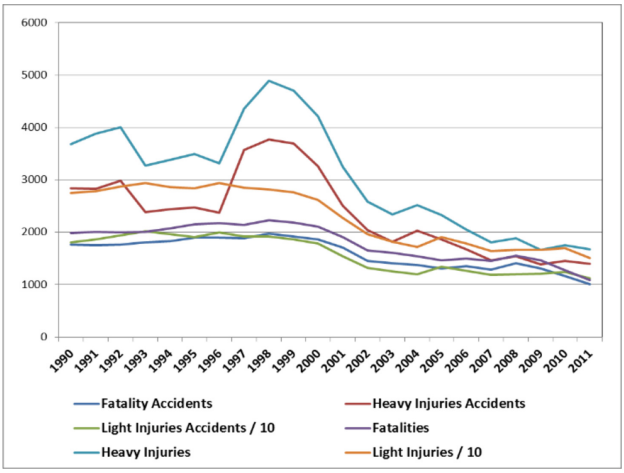


Fig. 2. Evolution of accidents, fatalities and injuries in Greece during period 1990–2010 (Own Process)

Table 1. Length (km) of Motorways in EU-27 for the year 2019 (Source: ERF, 2019 [3])

	Motorways	Total	Motorways /Total (%)
BE	1,763	2,075,018	0.1%
BG	740	969,583	0.1%
CZ	1,223	1,862,624	0.1%
DK	1,255	1,920,316	0.1%
DE	12,996	937,061	1.4%
EE	145	1,733,026	0.0%
IE	916	1,846,097	0.0%
GR	1,843	718,244	0.3%
ES	15,444	1,658,791	0.9%
FR	11,612	1,736,503	0.7%
HR	1,310	601,171	0.2%
IT	6,943	1,000,755	0.7%
CY	272	644,478	0.0%
LV	–	575,727	-
LT	314	748,368	0.0%
LU	161	634,719	0.0%
HU	1,924	505,761	0.4%

(*continued*)

Table 1. (*continued*)

	Motorways	Total	Motorways /Total (%)
MT	–	676,774	-
NL	2,758	630,070	0.4%
AT	1,743	299,357	0.6%
PL	1,640	672,279	0.2%
PT	3,065	490,469	0.6%
RO	747	163,314	0.5%
SI	773	252,910	0.3%
SK	463	478,758	0.1%
FI	890	77,091	1.2%
SE	2,118	212,787	1.0%

In Table 2, the average yearly motorway fatalities in European countries are displayed against relevant figures in Greece (2000 – 2019). Fatalities are presented in rounded 4-year periods. This is to reduce both the extent of the Table and the noise of a year-to-year variations, which may obscure the real trend. Comparably to countries of similar extent, bigger figures are acknowledged for Greece. In addition, the decline of the fatalities is not as sharp as in other States. Data for Tables 2 and 3 have been extracted and aggregated by different sources [4–7].

Table 2. Average yearly fatalities along European countries' motorways (Source: ERF, 2019 [3])

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
GR	80	110	90	70	50
AT	180	110	80	50	35
BE	200	150	110	100	100
CZ	45	40	30	30	25
DE	800	690	440	400	400
DK	40	40	35	15	15
ES	360	160	90	70	80
FI	20	15	10	10	5
FR	560	330	270	240	280
HU	50	60	45	30	
IE	5	10	10	10	5

(*continued*)

Table 2. (*continued*)

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
IT	770	700	380	220	280
LT			30	15	10
LU	100	85	60	75	70
NL	50	35	40	50	70
PL	130	110	110	65	50
PT	30	25	20	30	25
SE	25	25	25	20	20
SI	200	200	110	100	100
UK	950	800	600	350	210

The temporal motorway fatalities increase in Greece during the period 2004–2007 is attributed to the coincidental sharp increase in the length of trafficked motorways.

During the last four-year period, an increase at motorway accident fatalities can be spotted in few countries as well as a stagnancy in many more. Actually, advanced in traffic safety countries, have achieved the peaks at traffic safety indices beyond which any improvement would be very difficult and marginal by existing means. Hopes for impressive further safety improvement are put on the eminent electronic and artificial intelligence evolutions.

Fatalities across the rest rural road network are presented in Table 3(2000 – 2019). It is necessary to show these figures as a reference, because the length of motorways may vary considerably, whilst the length of the primary and secondary rural roads are almost constant and representative to the extent of each country. Empty slots means that relevant data could not be found.

Table 3. Average yearly fatalities along European countries' rural roads (Source: ERF, 2019 [3])

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
GR	950	800	600	350	210
AT	550	460	340	170	170
BE	840	640	460	350	310
CZ	800	600	490	460	360
DE	300	200	140	120	110
DK	4500	3000	2400	2400	2200
ES	4500	3000	1900	1250	1350

(*continued*)

Table 3. (*continued*)

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
FI	300	270	210	200	170
FR	5300	3300	2600	2200	2400
HU	750	750	460	360	
IE	300	290	150	130	120
IT	3000	3100	2100	1600	1900
LT			530	250	130
LU	70	50	40	30	10
NL	560	400	260		
PL	3000	3000	2400	1800	1600
PT	950	690	400	240	170
SE	400	300	220	190	240
SI	170	100	100	50	30
UK	2400	2200	1300	1200	1200

It should be mentioned that Table 3 does not present all the other fatalities along European countries road network. There are few fatalities in lower hierarchy rural roads, as well as quite strong figures in urban areas. Comparably to countries of similar population to Greece, bigger figures are again acknowledged for Greece. However, the improvement of road safety in terms of fatalities decline is quite noticeable as in other States. Greece having the most unfavourable starting point, achieves rival safety improvements. It worth mentioning that Greece lags analogue EU countries by almost twenty years.

However, the proper denominator should be neither country's extent nor population. The proper denominator over which all traffic accident figures should be reduced is the relevant number of the travelled vehicle-kilometres. This best measures the exposure to traffic incidents. Vehicle-kilometres per road type is a difficult figure to be obtained. Consequently, the second best ratio would be used, that of fatalities to the length of the relevant category road network. This is considered a better indicator than that of the number of registered vehicles, because the study is concentrated in motorways. Table 4 presents average yearly fatalities in 4-years sub periods per motorway kilometre along European countries.

Figures for travelled vehicle-kilometres along motorways are available for Greece. The ratio of motorway fatalities to travelled vehicle-kilometres are presented in Table 5.

The trend, as well as the rate of reduction is similar to that of Table 4. This secures the conclusion drawn by studying Table 4 only. During 2019–2021, EU's-27 average number of fatalities per million population were 51, 42 and 44, for Greece the respective numbers were 64, 54 and 57. Although in Greece in 2021 the number of fatalities per million population due to road accidents was decreased by 12% when compared to 2019, when compared to 2020 it was increased by 5% [8].

Table 4. Average yearly fatalities per motorway km along European countries (Source: ERF, 2019 [3])

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
GR	0.12	0.11	0.07	0.05	0.04
AT	0.11	0.07	0.05	0.03	0.02
BE	0.05	0.05	0.04	0.03	0.02
CZ	0.05	0.05	0.04	0.03	0.02
DE			0.09	0.05	0.03
DK	0.09	0.06	0.05	0.03	0.02
ES	0.05	0.05	0.05	0.04	0.03
FI	0.12	0.07	0.05	0.03	0.02
FR	0.02	0.01	0.01	0.01	0.01
HU	0.05	0.04	0.03	0.03	0.02
IE	0.03	0.02	0.02	0.01	0.01
IT	0.04	0.04	0.03	0.03	0.02
LT	0.02	0.02	0.01	0.01	0.01
LU	0.07	0.06	0.04	0.03	0.03
NL	0.04	0.02	0.01	0.01	0.01
PL	0.06	0.04	0.03	0.02	0.02
PT	0.1	0.1	0.07	0.04	0.03
SE	0.08	0.05	0.05	0.05	0.05
SI	0.06	0.06	0.04	0.03	0.03
UK	0.12	0.08	0.04	0.03	0.03

Table 5. Average yearly fatalities per 10^9 vehicle-kilometre along Greek motorways

Country	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
GR	20	13	11	8.5	6.5

Generally, to compare traffic safety indices along motorways is the safest way to evaluate certain traffic safety issues. Motorways have the most consistent and of high quality characteristics in all countries, thus traffic safety indices along them reflect differences mainly in traffic monitoring and policing, speed limits and driver's behaviour. Delving into Table 4 figures, Greece has systematically the worst traffic fatalities ratios. However, these ratios are not as bad as the absolute figures presented in Tables 2 and 3, relatively to the rest EU countries. The sharp increase in Greek motorway network during the 20-year period of the study improved the traffic accidents' fatality ratio.

However, in 2019 Greek motorway fatality ratio remains one of the highest. First parameter to explain that is the poor policing applied along Greek motorways. The operation and utilization of Greek motorways belongs mostly to the private sector. Traffic monitoring is in a European average level, but traffic policing lags. In addition, vehicles' age is higher comparing to other European countries, but very few accidents (2%) are mainly attributed to vehicle failures [9]. Greek driver's behaviour is rather aggressive. They ignore Highway Codes suggestions mainly due to the poor policing. Driver's behaviour is generally the main cause of traffic accidents and the leading variable explaining the worse than average Greek motorway safety performance.

It is a principle that comparisons are more realistic under similar conditions. In Table 4, European countries independently their size, terrain type or traffic safety culture are presented. The ragged terrain of Greece has no match to many other EU countries. Thus, it would be interesting to constrain the comparison among same size countries to Greece. In Fig. 3 the average yearly fatalities in 4-years sub periods per motorway kilometre for similar to Greece EU countries is presented. As such, Czech, Hungary, Eire, Lithuania and Portugal have been selected. Greece has, historically, the poorest traffic safety records among EU countries, thus it would not be proper and realistic to be compared with other similar to population countries like the Netherlands, Belgium or Denmark, having excellent traffic safety performance for decades. The case of Austria is different, as Austria is the only EU country having a similar (actually more) ragged terrain to Greece. The comparison of Austria versus Greece is independently presented in Fig. 4.

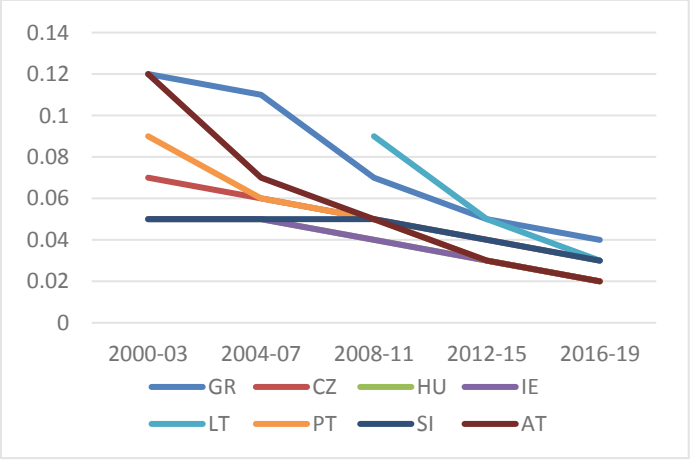


Fig. 3. Motorway fatality numbers for similar to Greece countries

Again, among somehow similar European countries, Greece has the poorest motorway safety records. Lithuania, a country recently entered the European Union, with poorer entry relevant records has outperformed Greece in 2016–2019 period. However, the differences are not prominent, motorway safety records for Greece (as already

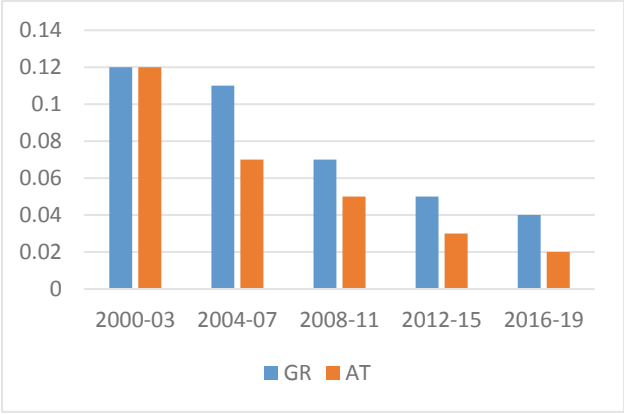


Fig. 4. Motorway fatality numbers for Greece and Austria (Own Process)

mentioned) are quite near to other similar European countries. According to firstly published statistics by the European Commission and republished by other sources, more than 22.500 people were killed in road accidents on motorways in the European Union countries between 2007 and 2016 [10]. Moreover, during this period (2007–2016) the annual fatalities per 1,000km of motorways were significant. The worst performance was reported in Bulgaria (83.1 fatalities per year and per 1,000km of motorways) while in Greece the respective number was 28.3, in Germany 30.2 and in Italy 39.5 [10]. Overall, Greece was ranked 11th among 22 European countries [10].

The same is valid for Austria as well, a country with better-established traffic safety culture (figures by Table 2) and a comparable to Greece ragged terrain. Actually, Austria and Greece have a similar motorway safety starting point (year 2000), but Austria achieved a better improvement during that 20-year period, being a more discipline and better-policed society.

A final aspect of European motorways' safety is presented in Table 6, which presents a comparison of an average percentage distribution of motorway fatalities per mode of transport for the EU-21 member states and Greece. The only figure that clearly differentiates between Greece and EU-21 countries are those of the contribution of lorries and 2-wheelers. Greece, lying at the edge of Europe, has the lowest percentage of lorries in her motorways. In addition, the mild climate of Greece encourages more kilometers to be travelled by 2-wheelers; therefore, the higher participation in traffic accidents of this mode of transport is considered as a surprise. It should be mentioned, however, that a typical motorway accident involving a 2-wheeler has higher death rates than one without a 2-wheeler. This observation may partly explain the higher fatality rates met along Greek motorways.

Greece's motorway network in Greece is presented in Fig. 5. In the framework of EN.I.R.I.S.S.T. project [11], a GIS map was developed, presenting the number of fatalities due to road accidents per a million of residents, clustered in four clusters and using as s geographical unit NUTS 3 regions (see Fig. 6).

Table 6. Comparison of % distribution of motorway fatalities per mode of transport (EU-21 versus Greece)

	Cars	Lorries	2weelers	Pedestrians	Others
EU-21	65.2%	13.5%	11.3%	8.2%	1.8%
GR	64.2%	6.7%	20.0%	8.2%	1.0%



Fig. 5. Motorway's network in Greece for the year 2022 (Source: [12])

It can be easily derived when comparing Figs. 5 and 6 that in NUTS 3 regions in which motorways are passing through, the number of fatalities is less than the rest, except from regions in Peloponnesus and Central Greece. It seems that motorways contribute to improve road safety levels for inter-regional movements.

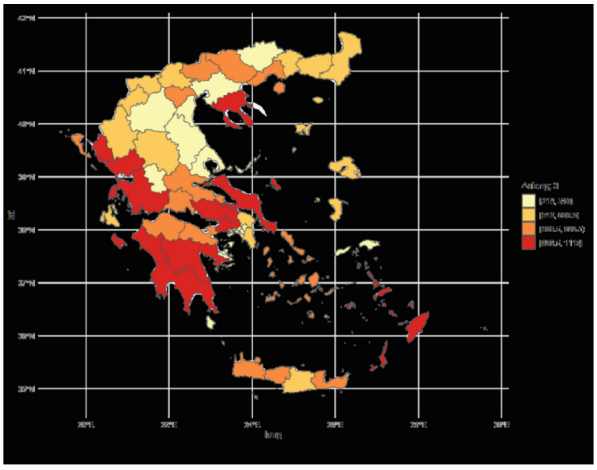


Fig. 6. Map of fatalities by road accidents per million of residents in NUTS 3 regions (2012–2019) (Source: [11])

3 Discussion and Conclusions

The design standards of motorways enhance by default higher levels of road safety. Along motorways, based on the above-mentioned statistical analysis, traffic accidents are not so often comparing to other road types. In this respect, the higher the percentage of motorways in the total road network the better the road safety in the country. During recent years (2000 – 2020), motorway construction plans in Greece flourish and the relevant figures have been noticeably improved and approach EU's averages. The most representative and impressive road safety indicator is the one concerning fatalities per kilometer of motorway network, which was reduced.

Greek motorways' safety, as expressed by fatalities per motorway length is worse than the EU's averages. Even for similar to Greece countries by size or by type of terrain, Greek motorways' safety performance lag by 20 to 50%. This lower performance may be attributed to deficient policing, more aggressive driving behavior and higher percentage of 2-wheelers. An in-depth examination of accidents along Greek motorways, as well as along the whole road network, is necessary in order to determine the most important causal factors.

The full application of a recently introduced safety audit methodology is expected to contribute towards this goal [13, 14]. Relevant projects have started to be undertaken during recent years along both motorways as well as the rest primary road network.

References

1. Papaioannou, D., Kokkalis, A.: Motorway safety in Europe and Greece: a comparative analysis. Elsevier Procedia – Soc. Behav. Sci. Transp. Res. Arena **48**, 3428–3440 (2012)
2. Eurostat, European Commission Statistics Database (2022). https://ec.europa.eu/eurostat/databrowser/view/sdg_11_40/default/line?lang=en
3. European Union Road Federation (2022). https://erf.be/statistics/road-network-2019/
4. Traffic Safety Basic Facts 2007, 2010, Motorways, DaCoTA Project, co-financed by the European Commission, Directorate-General for Mobility and Transport. http://www.dacota-project.eu/index.html
5. Eurostat, European Commission, Statistics Database. http://epp.eurostat.ec.europa.eu/
6. ERSO (the European Road Safety Observatory), Road Safety, CARE database – reports and graphics, European Commission
7. International Transport Forum, Statistics Briefs. http://internationaltransportforum.org/statistics
8. Assocation Europeene des Concessionnaires d' Autoroutes et d' Ouvrages a Peage (ASECAP). http://www.asecap.com
9. Road Safety in the EU: fatalities in 2021 remain well below pre-pandemic level. Directorate-General for Mobility and Transport, European Commission, Online article. https://transport.ec.europa.eu/news/preliminary-2021-eu-road-safety-statistics-2022-03-28_en
10. Mungnimit, S., Jierranaitanakit, K., Chayanan, S.: Sequential data analysis for black spot identification. In: 4th IRTAD Conference, 16–17 September, Korea (2009)
11. How many people die on European motorways? Statista (2021). Online article. https://www.statista.com/chart/25098/fatality-rate-and-speed-limit-on-european-motorways/
12. EN.I.R.I.S.S.T. Project, Deliverable 5.3.5.1, Implemented under the action "Reinforcement of the Research and Innovation infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation", co-financed by Greece and the European Union (European Regional Development Fund) (2022)

13. Wikipedia, National Roads and Motorways in Greece (2022). [File:Greekmotorways2017 2.jpg|Greekmotorways2017 2], CC BY-SA 4.0
14. PIARC Road Safety Manual, PIARC (2015)
15. Quantifying safety in the road safety audit process, US Dpt. of Transportation (2015). https://safety.fhwa.dot.gov/tools/crf/resources/cmfs/