Lowering the speed limit to 80 km/h

Final assessment report

July 1 2020

Delegation for road safety

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Conclusion

Following a government decision, the measure to lower the speed limit from 90 km/h to 80 km/h on two-way rural roads without a central separator in mainland France was implemented on 1 July 2018. Its main objective was to reduce the number of deaths and injuries on the roads affected by the measure.

It was decided to carry out an in-depth assessment in July 2020. This mission was entrusted to Cerema by the Interministerial Delegation for Road Safety.

To do this, a method was deployed based around four themes: speeds, accident rates, acceptability and effects on society. A socio-economic calculation was also made. Based on a scientific approach, this method was submitted for review by national and international experts.

The Covid19 pandemic severely disrupted travel in France in the first half of 2020, both in terms of volume and structure. It compromised the collection of some data in the early part of the year. This context led to the evaluation being carried out over the 18 months following implementation of the measure, i.e. from July 2018 to December 2019.

A reduction in speeds as of 1 July 2018

Lowering the speed limit has a non-linear impact on speeds. For example, in the context of the 80 km/h measure, a 3.3 km/h drop in the average speeds of all users was recorded by the Cerema observatory. This drop is in line with the findings of the international literature.

1 July 2018 marks a real break in the changes in speeds on the roads impacted by the measure. The drop in speeds was a long-term trend until December 2019. This applies to all speeds, including the fastest ones. The difference between the slowest and fastest speeds remains stable.

A very significant drop in the number of deaths on the network concerned

The impact of the measure corresponds to a 12% decrease in the number of deaths on the considered network, the network excluding urban areas and motorways, compared to the rest of the French road network (with an estimated error of 3.6%). For the 18 months after the implementation of the measure, where the data are final, a decrease of 331 deaths on the considered network is to be observed, compared to the reference period 2013-2017. Taking into account the months of January and February 2020, where data are estimated, the decrease in the number of deaths amounts to 349 over 20 months.

Over the rest of the French road network, the change is different, the number of deaths remaining stable compared to the reference level.

The impact of the measure on the number of injury accidents is less marked. On the considered network, it is stabilized at the reference level. However, the reduction in the severity of accidents should be noted, with a 10% drop in the death rate.

An increase in travel time that is less than users perceive it to be

In terms of traffic, the Cerema observatory did not note any impact on traffic flow caused by the measure. Indeed, no additional platoons were created, nor was there a reduction in the time between vehicles following each other.

On the other hand, an average increase in travel time of 1 second per kilometre was calculated, using a comparative analysis of a history of floating vehicle data over a period of three months in 2017 and 2019.

For journeys of 50 kilometres, this corresponds to a loss of 50 seconds on weekdays. This is far less than the time lost as users perceive it; they tend to overestimate the time saved when they drive quickly. In surveys conducted in October 2019, respondents reported losing over 2 minutes for this type of trip.

A slight improvement in environmental impacts

With regard to environmental effects, the analyses showed that the measure led to a slight decrease in the main air pollutants and noise pollution, although the latter is not perceptible to the human ear. The results obtained, although modest, are consistent with previous literature on the subject.

Acceptance of the measure continues to grow

Acceptance of the measure has continued to improve since its implementation. The proportion of people in favour of the measure increased from 30% in April 2018 to 43% in October 2019 and 48% in June 2020.

The positive change was strongest among people who “strongly disagree” with the measure, with their proportion rising from 40% in April 2018 to 23% in October 2019 and 20% in June 2020. This change is particularly pronounced among people living in rural areas and in towns with populations of less than 20,000.

Surveys, in conjunction with previous literature, have shown that the drop in accident rate and particularly deaths has had a positive impact on the level of acceptance of the measure.

A positive socio-economic assessment showing the efficiency of the measure

The estimated socio-economic balance sheet leads to a gain of €700 million over one year, comparing 2017 and 2019.

The socio-economic balance sheet shows that the measure is definitely efficient, with low investment costs as well as positive results in terms of achieving benefits to society in relation to costs to it. The benefits to society mainly lie in an improved accident rate (€1.2 billion). They are consistent with the expected effect of the measure. The main social cost of the measure is related to the loss of travel time (between €720 and €920 million). It is largely offset by the reduction in accident rates, to which are added the benefits of lower fuel consumption and lower CO_2 emissions.

Ultimately positive results that would be even better if the speed limits were better respected.

The measure has not yet fully achieved its intended effects. In December 2019, 58% of light vehicle drivers were still driving at speeds above 80 km/h, and 35% of these were between 80 and 90 km/h. The literature indicates that speeding below 10 km/h is mainly perceived by road users as not very dangerous and reprehensible, even though it plays a significant role in French road deaths.

There is therefore still room for improvement in terms of compliance with speed limit. The steady increase in drivers subscribing to the measure gives reason to hope for an improvement in compliance with it.

Contents

Preamble: the assessment mission

The French Interministerial committee for road safety of 9 January 2018 proposed 18 measures to combat road safety issues[1].

The fifth measure involves reducing the speed limit from 90 km/h to 80 km/h on two-way rural roads with no central separator in mainland France. The decision was taken to make this measure effective on July 1, 2018.

In order to ensure close monitoring of the measure implemented, it was decided to carry out an in-depth assessment after two years. This assessment was entrusted to the *Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement* (Centre for Studies on Risks, the Environment, Mobility and Urban Planning (Cerema)) which received a letter of engagement from the Interministerial Delegation for Road Safety on April 27, 2018.

This letter detailed the general purpose of the mission, namely "the assessment of the interdepartmental measure to reduce the speed limit to 80 km/h on two-way roads without central separator in mainland France", referred to in the report as VMA80 , along with four "special topics" which were to be addressed in the report: changes in speed, changes in injury accidents and in particular road deaths, the acceptability of the measure and the cultural change it induces, and the qualitative and quantitative analyses of the effects on society .

The letter gave the overall deadline, indicating that the assessment of the measure "would be published two years after its implementation, i.e. in July 2020".

The letter listed a series of evaluative questions that guided the definition of the methodology, which are given in the appendix 1.

This report presents the results of the assessment of the 80 km/h measure.

[1]All these measures can be consulted via the following link: https://www.gouvernement.fr/sites/default/files/document/document/2018/01/dossier_de_presse_-_comite_interministeriel_de_la_securite_routiere_-_mardi_9_janvier_2018.pdf

1 - Context and objectives of the 80 km/h measure

1.1 - History of the 80 km/h measure

Since 1972, many policies and measures have been implemented to reduce road accidents. Among the main ones, mention may be made of the following: applying a general speed limit in interurban areas (1974), lowering blood alcohol limits (1987), lowering speed limits in towns (1990), the introduction of the points-based licence (1992), the introduction of automatic speed cameras (2002), and the abolition of the presidential amnesty for road traffic offences (2007).

They form part of many other actions to promote road safety, such as those relating to the improvement of infrastructure by road managers or of vehicles by manufacturers. They were also accompanied by awareness-raising and prevention programmes for road users.

These actions are bearing fruit, with a sharp drop in the number of deaths during the decade beginning in 2000. However, since 2013, the number of road deaths has remained stable or even increased slightly.

In November 2012, the French Minister of the Interior announced a goal to reduce the number of deaths to fewer than 2,000 by 2020, or a 50% decrease.

In November 2013, the Committee of Experts of the French National Road Safety Council (Conseil National de la Sécurité Routière - CNSR) issued a report of proposals to halve the number of people killed or seriously injured in road accidents by 2020. This report proposes four measures to achieve this goal, one of which is to reduce the speed limit from 90 to 80 km/h on two-way roads. A saving of 350 to 400 lives per year was estimated if the measure was applied to the entire two-way network limited to 90 km/h and if the average speed were effectively reduced by 5 km/h. This fairly ambitious hypothesis was made as part of efficient enforcement.

At the plenary session of the French National Road Safety Council (CNSR) of 11 June 2014, the Minister of the Interior announced his intention to begin an experiment in this area. The selected routes were officially presented to the plenary session of the CNSR on May 11, 2015. These were three national road routes over a distance of 86 kilometres (RN 57 Vesoul - Rioz, RN 151 Auxerre - La Charité-sur-Loire and RN7 Crozes-Hermitage - Valence). The experiment took place from July 2015 to July 2017.

The Cerema assessment report showed that lowering the speed limit from 90 km/h to 80 km/h led to an average decrease in speeds of 4.7 km/h, all vehicles combined, of 5.1 km/h for light vehicles and 2.7 km / h for heavy goods vehicles (Cerema, 2017). This drop affects all categories of vehicles and all users, regardless of their driving habits. The highest speeds also fell compared to the initial situation. This decrease is also reflected in a decrease in the inconvenience caused by HGVs driving during the experiment with a lower speed difference as compared with light vehicles. No significant shift of traffic onto bypass routes was observed. However this experiment had nothing to say about changes in the accident rate. This was because the limited number of kilometres concerned made satisfactory statistical analysis impossible (ONISR, 2018a).

The French Interministerial committee for road safety of 9 January 2018 proposed 18 measures to combat road safety issues[2]. **The fifth measure involves reducing the speed limit by 10 km/h on two-way rural roads with no central separator in mainland France.** The decision was taken to make this measure effective on July 1, 2018.

[2]All these measures can be consulted via the following link: https://www.gouvernement.fr/sites/default/files/document/document/2018/01/dossier_de_presse_-_comite_interministeriel_de_la_securite_routiere_-_mardi_9_janvier_2018.pdf

The measure targets the two-way network in the open countryside because this is the one with the greatest impact on road deaths. In 2017, it represented 56 % of all road deaths (ONISR, 2018b). It was decided to apply the measure to the entire network because the roads where most of the traffic flows are those where the majority of the people killed are concentrated. It has been shown that at national level, 20 % of the road network outside urban areas accounts for 55 % of deaths (ONISR, 2018c) and that the departmental main road network accounts for 67 % of deaths outside urban areas (Cerema, 2014).

1.2 - Objectives of the 80 km/h measure

The measure to lower the maximum permitted speed by 10 km/h on the two-way network without a central separator in mainland France is therefore part of a national policy to reduce the total number of people killed in road accidents, a policy which was reasserted in 2012 by the Minister of the Interior.

The main objective of the measure is to reduce the number of fatalities and injury accidents on the roads affected by the measure.

Two strategic objectives were also assigned[3]:

- encourage a reduction in the average speed that road users drive at,
- combat excessive speeding,

along with five intermediate objectives:

- encourage drivers to overtake less,
- help to reduce polluting emissions released into the environment,
- to make road traffic more fluid,
- help to reduce the severity of impact in the event of an accident,
- help to reduce braking distances to prevent an accident.

1.3 - The subject of mobility on the political agenda

The implementation of the 80 km/h measure is part of a general context of bringing the subject of mobility onto the political agenda and revealing the concerns of the French with regard to this issue.

The French inland transport organisation law of 30 December 1982 established the general legal framework for transport in France and how it is to be organised. However, since this law was adopted, the transport sector has undergone major changes such as the development of shared mobility. It therefore appeared necessary to define a new mobility policy to meet these new challenges and the new expectations of users. This is the purpose of the framework law on mobility which was enacted in December 2019.

To prepare for it, the government launched the national mobility conference (Assises Nationales de la Mobilité) in 2017. In this context, the French were asked to express their expectations regarding their daily mobility from 19 September to 13 December 2017. This public participation followed on from the preliminary draft of the National Transport Infrastructure Plan (Schéma National des Infrastructures de Transports) (2009) and the Mobility 21 Commission (Commission Mobilité 21) (2012) focused on ranking priority and sustainable investments. The workshops in peri-urban areas and in rural areas found that public transport was insufficiently dense, frequent and reliable. It was stated that this was leading to major territorial divides and massive use of the private car, as the transport offer was insufficient to allow people to leave their seclusion. Equal access to mobility has been a recurring theme of discussion. The problem has turned out to be particularly acute in rural areas.

[3]These objectives are detailed in the DSR's mission letter to Cerema dated 27 April 2018.

In 2018, renewed inflation linked to the rise in crude oil prices, in a context of fiscal measures (an increase in the social security contribution and energy taxes), combined with a decrease in the taxation of capital income, was causing social discontent. Several events relayed by social networks to protest against the increase in fuel taxes marked the birth of the “gilets jaunes” (yellow jackets) movement. The protest movement blocked roads all over France on 17 November 2018. This was followed by regular events (on Saturdays), with decreasing intensity from the beginning of 2019.

In 2019, the great national debate was officially held from 15 January to 15 March. This was the response of the Head of State to the “gilets jaunes” movement: to allow the French to air their grievances. Rejection of the 80km/h speed limit accounted for 15% of the free contributions to the debate. The assumed increase in travel time for road users is most often cited in media opposed to the measure.

In March 2019, an amendment adopted by the upper house of parliament gave the presidents of the departmental councils (for departmental roads) and the prefects (for national roads) the authority to raise the speed limit on roads affected by the 80 km/h measure. Their decision must be taken after consulting the departmental road safety commission. This amendment was examined and then adopted as part of the framework law on mobility, enacted in December 2019. In early 2020, some departments started to raise the speed limit back to 90 km/h on certain sections. The department of Haute-Marne was the first to do this in January 2020.

In 2020, the Covid19 pandemic had a strong impact on mobility as shown in the traffic figures in the following section.

1.4 - Changes in road traffic volumes

On all road networks in mainland France, domestic passenger transport in private vehicles grew steadily from 1990 to 2017 and then stagnated in 2018 (table 1)[4]. Growth averages 1.2% annually from 2013 to 2017. It stabilized in 2018 (+0.0%) in a context of sharp increases in fuel prices at the pump (+16.6% for diesel and +9.2% for unleaded petrol).

This development is of the same kind for the national network (motorways, urban expressways and national roads) and for the local network (departmental, metropolitan and communal roads). However, the values are given by the statistical service of the Ministry for Ecological and Inclusive (Ministère de la transition écologique et solidaire - SDES) on an aggregated basis and cannot be dissociated to reconstitute the network affected by the measure, which includes some of the national roads and departmental roads.

In addition, the overall traffic volume in France on all networks is not yet available for 2019.

G1.c Circulation par réseau*

en milliards de véhicules-kilomètres

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total autoroutes (1)	86,8	91,7	94,5	100,2	106,0	111,0	115,0	118,8	126,1	133,0	139,1	145,0	149,8	152,3
Autoroutes concédées	42,5	45,0	46,9	49,4	52,2	54,0	54,9	56,8	59,9	63,7	65,8	69,3	72,6	74,4
Autoroutes non concédées (1)	44,3	46,6	47,6	50,7	53,9	57,0	60,1	61,9	66,2	69,3	73,2	75,6	77,2	77,9
Routes 'nationales'	18,9	19,1	19,2	19,5	19,9	20,2	20,6	21,0	21,6	22,0	22,1	22,5	22,9	23,2
Total réseau 'national'	**105,6**	**110,8**	**113,6**	**119,6**	**126,0**	**131,2**	**135,5**	**139,8**	**147,7**	**155,0**	**161,2**	**167,5**	**172,7**	**175,5**
Autres routes (2)	**314,2**	**317,4**	**327,1**	**326,8**	**328,6**	**334,5**	**335,0**	**341,7**	**350,9**	**359,3**	**357,1**	**371,5**	**375,1**	**377,2**
Ensemble des réseaux	**419,8**	**428,2**	**440,7**	**446,5**	**454,6**	**465,7**	**470,6**	**481,5**	**498,6**	**514,3**	**518,2**	**539,0**	**547,8**	**552,7**

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total autoroutes (1)	156,6	157,3	160,6	164,9	162,3	164,2	168,2	171,0	168,4	169,5	172,7	178,5	181,7	185,9	185,4
Autoroutes concédées	76,3	77,3	79,3	82,0	81,3	82,3	84,1	85,3	83,7	85,2	87,3	89,7	92,6	94,4	95,0
Autoroutes non concédées (1)	80,3	80,0	81,3	82,9	80,9	81,9	84,0	85,7	84,7	84,3	85,4	88,8	89,1	91,5	90,4
Routes 'nationales'	23,4	23,4	23,4	23,5	23,1	23,5	23,3	23,1	22,7	22,4	22,8	22,4	21,9	22,9	22,4
Total réseau 'national'	**180,1**	**180,7**	**184,0**	**188,4**	**185,4**	**187,8**	**191,4**	**194,1**	**191,1**	**191,9**	**195,5**	**200,9**	**203,7**	**208,7**	**207,9**
Autres routes (2)	**377,0**	**373,6**	**371,2**	**373,3**	**367,3**	**364,5**	**369,1**	**370,8**	**372,6**	**375,9**	**376,9**	**384,0**	**396,0**	**397,3**	**398,4**
Ensemble des réseaux	**557,1**	**554,3**	**555,2**	**561,6**	**552,7**	**552,2**	**560,4**	**565,0**	**563,7**	**567,8**	**572,4**	**584,9**	**599,6**	**606,0**	**606,3**

Source : SDES-Bilan de la circulation d'après SDES, CCFA, Setra, Asfa, Kantar-Worldpanel, TNS-Sofres, CPDP

(*) ventilation de la circulation en tenant compte du nouveau réseau routier national : le réseau transféré aux collectivités locales en 2006 est inclus dans les "autres routes' depuis 1990 (série homogène sur toute la période)

l'ensemble des séries constitutives du bilan de la circulation a été rebasé en 2011. Voir annexe du 48ème rapport à la CCTN (tome 1).

(1) les voies rapides urbaines et les routes nationales interurbaines à caractéristiques autoroutières sont incluses dans les autoroutes non concédées

(2) routes départementales et réseau local, calcul par solde

Table 1 summary of traffic volumes in France from 1990 to 2018 in billions of vehicles.kilometers (Source: SDES)

Overland freight transport is still on the rise but at a lower rate (+2.2% in 2018, after +6.1% in 2017).

[4] In the table, “autoroutes” means “motorways”; “routes nationales” means “national roads”; “autres routes” concerns the local network (departmental, metropolitan and communal roads).

According to the national transport accounts, greenhouse gas (GHG) emissions from transport decrease in 2018 after three consecutive years of increase due to improvements in vehicle energy performance and the stabilization of passenger vehicle traffic.

Exprimé en 100 millions de véhicules km													Total 2017
	janv-17	févr-17	mars-17	avr-17	mai-17	juin-17	juil-17	août-17	sept-17	oct-17	nov-17	déc-17	
Total autoroutes	129,933376	130,601987	143,775464	157,394592	155,308886	159,276667	188,809284	188,219297	156,302319	156,217432	138,728125	145,958498	1850,52593
> Autoroute concédée	61,548	64,778	68,872	80,893	78,074	80,425	103,831	106,385	78,932	76,254	66,007	72,571	938,57
>Autoroute non concédé	68,3853758	65,8239872	74,903464	76,5015915	77,2348861	78,8516669	84,9782843	81,8342974	77,3703194	79,9634317	72,7211252	73,3874977	911,955927
Routes nationales	16,847422	16,7609013	18,5893893	18,7676812	19,5891222	20,2265895	21,5531504	20,933474	19,5209922	19,8554349	17,9281001	17,8449567	228,417214
Total réseau national	146,780798	147,362889	162,364853	176,162273	174,898008	179,503256	210,362435	209,152771	175,823312	176,072867	156,656225	163,803454	2078,94314
	janv-18	févr-18	mars-18	avr-18	mai-18	juin-18	juil-18	août-18	sept-18	oct-18	nov-18	déc-18	Total 2018
Total autoroutes	134,174607	126,836915	149,178509	157,756779	161,825592	160,825233	189,24462	190,946133	157,851579	157,531993	131,484474	137,767355	1855,42379
> Autoroute concédée	64,238	62,308	74,243	81,347	83,82	82,835	105,494	109,675	81,238	77,498	61,283	65,778	949,757
>Autoroute non concédé	69,9366072	64,528915	74,9355086	76,4097788	78,005592	77,9902328	83,7506197	81,2711331	76,6135791	80,0339933	70,2014744	71,9893549	905,666789
Routes nationales	17,3918177	16,1368827	18,4734627	18,4741835	19,3572164	19,7896358	21,1857075	20,6511437	19,001277	19,5505281	16,890193	17,0787322	223,98078
Total réseau national	151,566425	142,973798	167,651971	176,230962	181,182808	180,614869	210,430327	211,597277	176,852856	177,082521	148,374667	154,846087	2079,40457
	janv-18	févr-18	mars-18	avr-18	mai-18	juin-18	juil-18	août-18	sept-18	oct-18	nov-18	déc-18	Total 2019
Total autoroutes	133,749746	132,412028	149,001422	160,799911	154,190745	166,648305	186,712518	193,45033	158,485479	159,767649	141,096515	155,327673	1891,64232
> Autoroute concédée	63,706	65,913	73,512	82,27	76,504	86,709	103,088	111,12	80,447	78,828	68,43	79,443	969,97
>Autoroute non concédé	70,043746	66,4990281	75,4894224	78,5299107	77,6867446	79,9393046	83,6245182	82,3303303	78,0384791	80,9396489	72,6665155	75,884673	921,672322
Routes nationales	16,5398108	16,2427632	18,0836207	18,3195511	18,6625086	19,5353273	21,0024301	20,4147664	18,8876926	19,4140463	17,5563327	17,9204203	222,57927
Total réseau national	150,289557	148,654791	167,085043	179,119462	172,853253	186,183632	207,714948	213,865097	177,373172	179,181695	158,652848	173,248093	2114,22159

Table 2 Changes in vehicles.km between 2017 and 2019 on the national road network (i.e. excluding the departmental network) (Source: Cerema, 2020)

On the national road network, road traffic data are available for 2019 (table 2)[5]. They show a slight increase (+1.6%) compared to 2018 but hide disparities: traffic on national roads is down 0.5% while traffic on motorways is up 1.9% (mainly on the non-concession network).

In 2020, the Covid 19 pandemic had a strong impact on road traffic. Traffic on the non-conceded national road network, made available on Cerema's dedicated platform (http://dataviz.cerema.fr/trafic-routier)[6] show a decrease of about 75% during the containment period (illustration 1).

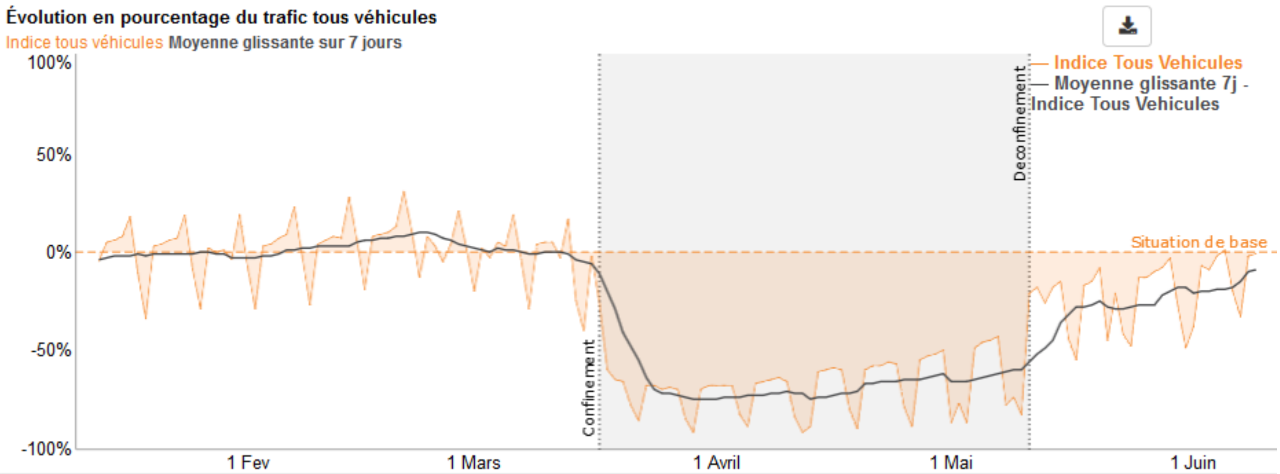


Illustration 1: Changes in road traffic volume on the national road network (i.e. excluding the departmental, communal and metropolitan networks) from January to June 2020 (Source: Cerema)

[5]In the table, "autoroutes" means "motorways"; "routes nationales" means "national roads"

[6]This site includes data from the non-concession national road network (sources: Bison Futé, Directions Interdépartementales des Routes, Stations de pesage dynamique) et de la Métropole de Bordeaux

The very structure of traffic was greatly affected, for example:

- congestion all but disappeared,
- owing to the confinement, travel beyond a few kilometres was allowed only in rare, mainly professional cases,
- commercial vehicles and HGV traffic, dedicated in particular to the delivery of essential goods, decreased in much smaller proportions than general traffic (by around -30% on average at one observation point on the national network in Nouvelle-Aquitaine, for example).

In mainland France as a whole, road traffic grew steadily until 2017 and then stabilized in 2018 (data are not available for 2019).

On national roads, some of which are affected by the 80 km/h measure, traffic has followed the same trend: steady growth until 2017 and then stagnation in 2018. In 2019, traffic decreased by 0.5%.

2 - Scientific literature related to the measure

The aim of the measure is to reduce the total number of deaths in France by reducing the operating speeds.

In this section, scientific references are presented. These concern:

- the relationship between operating speed and fatal accidents,
- the relationship between the speed limit and the operating speed,
- the principles of acceptance and acceptability of speed limits.
- the effects of speed limits on the environment,
- economic analysis of road safety policies.

2.1 - Fatal accidents: the impact of speed

The international literature shows that the impact mechanism of speed on road safety is twofold: speed plays a role in (a) the risk of an accident occurring and (b) the severity of the accident (e.g. among the most recent articles: Jurewicz et al., 2016 ; OECD, 2018 ; Castillo-Manzano et al., 2019 ; Elvik et al., 2019).

Speed therefore plays a part in all accidents, whatever their causes.

The exact relationship between speed and accidents on a given road or in a given area depends on a series of road and traffic characteristics that interact with speed.

Aarts and Van Schagen (2006), in a review of the international literature, showed that Nilsson's (2004) model was the best one to describe the relationship between crash risk and average speed. Nilsson showed that a 10% increase in average speed results in an increase of about 20 % in the frequency of accidents with injuries, of 30 % in that of serious accidents and of 40 % in that of fatal accidents (Nilsson, 2004). These results mainly concern rural roads and motorways. In early 2019, these results were reconfirmed based on more recent international data (Elvik et al., 2019).

A similar relationship has been calculated in Great Britain, based on empirical studies by Taylor (2000; 2002), where it was shown that changes in the number of crashes associated with a change in speed of 1 km/h ranged from 1 to 4% for urban roads and from 2.5 to 5.5% for rural roads, with the lower value reflecting good quality roads and the higher value reflecting poorer quality roads.

The study by Elvik (2013) has shown that the relationship between speed and road safety depends not only on the relative speed change, as suggested by the power model, but also on the initial speed. In other words, the effects of a change of speed on accidents are greater when the initial speed is high.

Furthermore, **speed plays an important part in the severity of accidents.**

The higher the impact speed, the more serious the consequences in terms of injuries and material damage. This is related to the dissipation of kinetic energy from the vehicle or vehicles just before impact. This depends on the mass of the vehicles and the square of their speed. Collisions at higher speeds and with a heavier vehicle can therefore have more serious consequences (Finch et al., 1994).

In addition, a driver needs a constant reaction time to react to unexpected events. The higher the speed, the greater the distance covered during this time and so the speed on impact will be high (Elvik, 2012; OECD, 2018). Appendix 2 presents the underlying physical laws in more detail.

At high speeds, speed differentials between users are detrimental as they increase potential conflict situations (Elvik, 2014). For example, the risk of rear-end collisions between slower and faster vehicles is higher.

Analysis of the factors contributing to fatal accidents in France confirms the results of the international literature.

An analysis of fatal accidents for the year 2015 was carried out by Cerema (Cerema, 2020*).* It was carried out using the sequential accident analysis method defined by INRETS, which, based on the reading of accident reports, makes it possible to retrace the history of the accident, identify malfunctions in the traffic system and define accident factors (Brenac, 1997).

The accident factor is a state of a component of the human/vehicle/infrastructure-environment system that was necessary (but not sufficient on its own) for the accident to occur (if this factor had not been present, the accident would not have occurred) and on which action might be possible. It therefore directly intervenes in the occurrence of the accident.

Excessive or inappropriate speed appears to be the first factor (37%) causing fatal accidents in 2015, involving at least one road user travelling on a two-way road limited to 90 km/h. The second is alcohol consumption (32%), followed by drug use (16%), fatigue (13%), lack of opportunity for recovery (12%) and refusing to give way (11%), to cite only the main ones. Accident factors can combine to lead to the occurrence of an accident; they are rarely mutually exclusive.

This confirms the results of the international literature which have shown that speed is the most important risk factor (e.g. Elvik, 2012).

2.2 - Relationship between the speed limit and the operating speeds

A distinction must be made between the speed limit (SL) and the operating speeds.

The speed limit is a statutory speed, which road users must not exceed, otherwise they will be fined. However, users may travel below the speed limit, depending on local traffic conditions and provided they respect any minimum authorised speeds.

So for a given SL, different actual speeds will be recorded. They correspond to the speeds at which road users actually drive, which are related to physical, climate and traffic conditions, such as bends, rain and congestion, and also to driver behaviour (see section 2.3).

The relationship between the speed limit and the speeds at which road users actually drive is not a linear one. Therefore, a change in the speed limit does not lead to a proportional decrease in the operating speeds (Elvik, 2012).

Using a meta-analysis, Elvik modelled the variation in speeds according to the differential of the speed limit on motorways. It is clear that the operating speeds change in the same direction as the SL. So if the SL is decreased, the operating speeds will be reduced. However, it has been found that increasing the SL has less of an impact on operating speeds than decreasing the SL. In addition, the meta-analysis showed that decreasing the SI by 10 km/h results in a 3 km/h reduction in average speed, although variability can be significant (Elvik, 2012).

In Sweden, a review of speed limits has been carried out since 2008 on the national rural road network. In particular the revision concerned a decrease on roads with a low level of safety (or 17,800 kilometres affected). On the rural network, which was reduced from 90 to 80 km/h, the assessment showed a 3.1 km/h decrease in speed and drop in the number of deaths per year of 14 representing a 41% decrease (Vadeby et Forsman, 2018).

The impact of speeding on road safety has also been studied.

Various international studies have shown that **drivers driving faster than the average speed have a higher risk of being involved in an accident** (Kloeden et al., 2002; Taylor et al., 2002). This risk is multiplied by two for a speed 10 km/h higher than the average speed. Having compared a number of modelling studies Aarts and Van Schagen (2006) concluded that Kloeden's (2002) model was the best one to describe the relationship between accident risk and individual speed. This risk modelling was confirmed by Brenac et al. (2016) based on a case-control study of accidents in France.

Using the Kloeden model on Australian urban roads with 60 km/h speed limits, Cameron (2013) showed that the relative number of crashes associated with speeds above 80 km/h was at least as high as the number associated with speeds in the 60-70 km/h range.

In Europe, it is estimated that 40-50% of drivers drive faster than the speed limit. In general, 10-20% exceed the speed limit by more than 10 km/h (European Commission, 2018).

In France, the study conducted by Cerema (Varin and Ledoux, 2018), based on a set of descriptive statistical analyses, provides a representative picture of the proportion of speeding vehicles involved in fatal accidents for the year 2011. It appears that 30% of fatal accidents on two-way roads outside urban areas involve a driver who is speeding.

Since 2003, a large number of speed cameras have been deployed in France. Viallon and Laumon (2013) have shown that this policy has led to a significant reduction in high speeding. Blais and Carnis (2015) showed that it had led to a 27% reduction in deaths per 100,000 inhabitants, or a total of 20,040 lives saved over the period 2002-2010.

However, Viallon and Laumon (2013) found a lower impact of the arrangement on speeding of less than 10 km/h (low level). They estimate, based on the power model they used, that the fraction of speed-related deaths that can be put down to speeding increased from 16% in 2001 to 46% in 2010.

In other words, the deployment of speed cameras in France has made it possible to reduce high speeding. **The lowest cases of speeding (less than 10 km/h over the limit) persist and account for a large proportion of fatal accidents.**

2.3 - Acceptance and acceptability of a speed limit

When a public policy is announced and then implemented, the public go through different phases before grasping it. The first concerns acceptability, which refers to the study of a public policy before it is put in place, while acceptance refers to the perception of that policy once it is effective, once users have been confronted with it.

Many studies have examined the acceptability of speed limits and show that different elements have an impact. Firstly, the characteristics of the drivers have an influence: those with a high score on the "sensation-seeking" scale (Zuckerman, 1979) are those with a big appetite for speed (Sartre, 2004). This intra-individual characteristic is related to the age of the respondents. Young drivers tend to be higher sensation seeker (Delhomme et al., 2012). On the other hand, female drivers find it less acceptable than male drivers to exceed the speed limit regardless of the network or the country where they live (Granié et al., 2020).

The literature on speed limit compliance often addresses one aspect of acceptability or acceptance of the measure and provides many lessons.

According to a Dutch study, on a road with a speed limit of 80 km/h, drivers reported driving 8 km/h above the speed limit (Goldenberg et Van Schagen, 2007). Such speeding is consistent with other researches showing **that respondents tend to drive 10% over the speed limit**, whether the limit is 60 km/h or 100 km/h (Fleiter et Watson, 2005).

Exceeding the speed limit by 10% is not considered risky behaviour by many road users. Several studies show that as long as drivers feel comfortable and in control of their vehicle, they do not consider exceeding the speed limit to be dangerous or morally reprehensible (Corbett, 2001). Users therefore tend to underestimate or ignore the risk associated with high speeds (Kanellaidis et al., 2000). More recent data show that 66.8% of French light vehicle users believe that exceeding speed limits increases the risk of accidents compared to 74.8% of European drivers (ESRA, 2018). Moreover, according to the same international study, 12.6% of French drivers find it acceptable “for them” to exceed the speed limit on roads outside built-up areas, excluding motorways and dual carriageways, compared with 10.6% of European drivers (ESRA, 2018).

Standards (especially descriptive standards) also appear to play a role in determining the operating speeds, more specifically the speeds at which other drivers drive. **A driver who thinks that the drivers he sees on the road are not respecting the speed limit will be more likely not to respect the speed limit himself** (Haglung et Aberg, 2000). In the same vein, according to Swedish drivers, it is more important to drive like everyone else than to respect the speed limit (Aberg, 1997). There is thought to be a connection between the tendency of French drivers to drive fast when in a hurry and the fact that these same drivers believe that other drivers behave in the same way (Cestac et al., 2018).

However, other motivations are put forward, such as saving time and therefore arriving earlier at one’s destination (for 32% of drivers) or at least not arriving late (57% of respondents) (Rowland et McLeod, 2017). **As a result, drivers tend to overestimate the time saved when driving fast** (Peer and Solomon, 2012).

On the other hand, **a positive impact in terms of reducing the number of accidents and their severity seems to be a convincing argument for complying with the speed limit** (Mc Guffie et Span, 2009). However, while drivers believe that speed can cause noise pollution and have a negative impact on the environment, these factors have very little impact on their decision to drive faster or slower (Elvik, 2010).

Some of the legal standards may be considered arbitrary, and may not meet a need, at least from the point of view of users, in terms of road safety. In certain situations, as this rule is not considered legitimate, it is not taken into account and only the fear of penalties makes users respect it. Regarding speed limits, for example, compliance with the 50km/h speed limit is considered a “perverse” rule, whereas the ban on drinking and driving seems legitimate (Havârneanu & Golita, 2010 in Granié, 2016).

2.4 - The effects of speed limits on the environment

Changes in speed can have an impact on pollutant emissions and noise pollution. In terms of pollutants, a distinction is made between pollutants with global impacts such as greenhouse gases (CO_2 and HFCs in particular) which contribute to global warming, and those with local and regional impacts on the environment, such as damaging ecosystems or materials, and on health (damage to the respiratory function, cancers, etc.).

A literature review by ADEME (2014) shows that with a reduction in the speed limit to 70 km/h instead of 90 km/h, greenhouse gas emissions (such as CO_2) estimated using microscopic methods fall by 4%. Only a small number of studies have been carried out to show the impact of lower speeds on CO_2 emissions and the results show differences depending on the types of models used.

This ADEME review (2014) also brings to light **a reduction in emissions/concentrations of local and regional pollutants with a decrease in speed**, as long as it does not fall below 80 km/h.

Speeds between 70 km/h and 90 km/h are the optimum (lowest) emission levels for nitrogen oxides and particulate matter in particular, with little or no variation in emissions at these speeds.

Illustration 2 shows the link between vehicle speed and nitrogen oxide (NOx) emissions:

- For an HGV: the lower the speed of the vehicle (from 90km/h), the more NOx it emits.
- For an LV: the more the speed of the vehicle decreases from 130km/h to 70km/h, the less Nox it will emit.

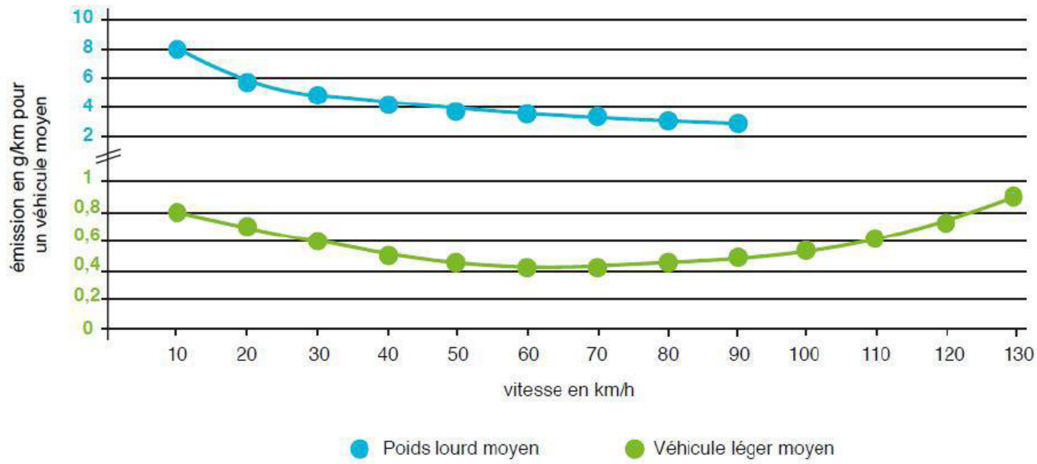


Illustration 2: Evolution of nitrogen oxide emission factors as a function of speed and the type of vehicle – HGV in blue and light vehicle in green (source: Air Languedoc Roussillon, 2012)

The regional association for air quality monitoring in Auvergne-Rhône-Alpes (Atmo ARA, 2018) shows in its assessment of the speed limit from 90 to 80 km/h (illustration 3):

- (i) a systematic decrease in pollutant emissions, the value of the decrease varying with the proportion of HGVs for which the speed limit is unchanged;
- (ii) a greater reduction for nitrogen dioxide and PM2.5 (down to minus 7%) for the lowest levels of HGVs;
- (iii) gains of no more than 3% for CO2 emissions.

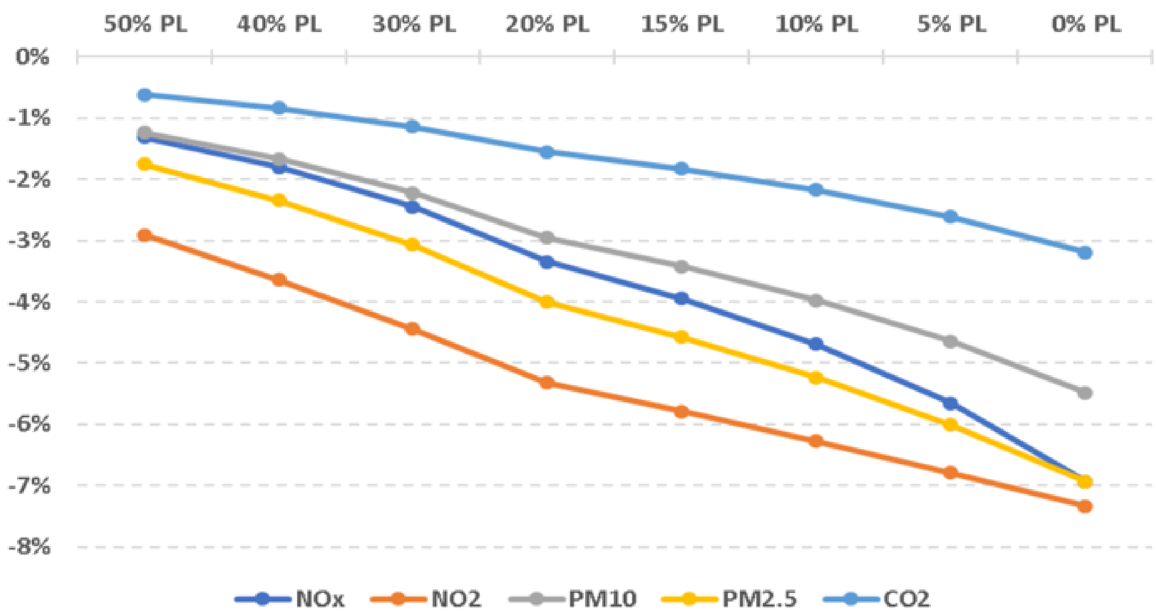


Illustration 3: impact of the speed limit on different pollutants depending on the proportion of HGVs (PL) (Source: ATMO ARA, 2018)

In addition, speed also contributes to the noise emission generated by a roadway, as do other factors (flow rate, number of HGVs, gradient, interaction between tyres and the roadway, etc.). For traffic speeds in excess of 50 km/h for light vehicles and 70 km/h for HGVs, the noise emitted by the contact between tyres and the roadway (rolling noise) is considered to be the predominant source of noise emitted by the vehicle.

As a first approach, the noise level emitted by a vehicle varies proportionally as a function of the logarithm of its velocity (approximate increase # 20 log v).

The diagram in illustration 4 shows the variation of maximum pass-by noise levels of a vehicle expressed in dB(A) as a function of speed. When speed is decreased from 90 to 70 km/h, these emission charts show an overall reduction of the noise emitted by the vehicle of around 2 decibels.

All other things being equal, **lowering the speed limit from 90 km/h to 80 km/h leads to a theoretical reduction of this noise of about 1 dB(A).** This theoretical reduction is calculated on the basis of the V80 indicator, an indicator used in acoustics, which characterises the speed exceeded by 80 % of vehicles.

From a physiological point of view, such a decrease is not perceptible to the human ear, which begins to detect a change in sound level from 2 dB(A) (Setra, Certu, 2001). This threshold of 2 dB(A) is used in French regulations to clarify the notion of significant modification to an existing road or rail infrastructure.

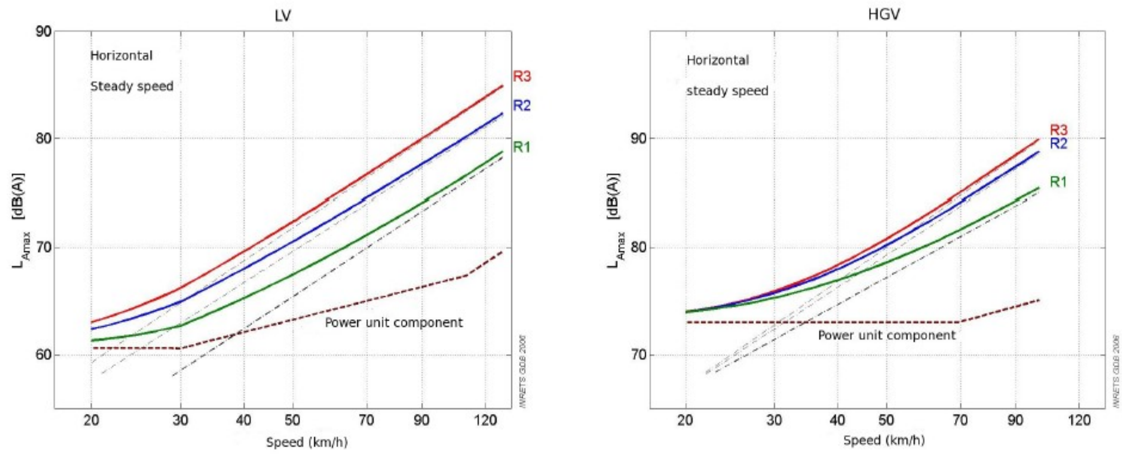


Illustration 4 : noise emission values (Lamax) of a light vehicle (left diagram) and a heavy goods vehicle (right diagram) as a function of speed (Source: SETRA,2009)

According to ADEME (2018), a bibliographical summary of case studies confirms, in the field, this generally low reduction in noise emissions with the reduction in speeds. This decrease varies from 0.2 to 3 dB(A) and tends to be more significant for initial speeds between 50 and 90 km/h (1 to 1.5 dB(A)) compared to those between 90 and 130 km/h (0.7 to 1 dB(A)).

For example, the study conducted by BruitParif (2014) on the impact of the move from 80 to 70 km/h on the Paris ring road in 2014 led to an average decrease of 0.5 dB(A) during the day and 1.2 dB(A) at night at 3 stations measured. In the case of the Rennes bypass (limited from 110 to 90 and 90 to 70 km/h), measurements taken at 5 points in 2015/2016 show differences of between -1 and +1 dB(A). These are below the measurement uncertainty.

The variation of the noise level also depends on the vehicle fleet. This is because, for the same speed, the lower noise reduction on HGVs covers the expected reduction on light vehicles. A large proportion of heavy goods vehicles may therefore mask all the benefit of speed reduction on light vehicles (ADEME, 2018).

2.5 - Economic analysis of road safety policies

The socio-economic assessment of infrastructure projects is governed by the government's instruction of 16 June 2014. It consists of determining the economic profitability of the project for the community, i.e. comparing the benefits created (time savings, safety, reduction in air pollution, etc.) and the negative consequences caused (noise, urban interruptions, etc.).

Since the 1950s there has been a great deal of research into the methods for the socio-economic assessment of transport infrastructure projects, particularly with regard to the valuation of the various costs and benefits associated with transport infrastructure or to the improvement of the various traffic forecasting models. Before being used, these are validated by a national scientific monitoring committee.

Official provisions have assigned a monetary valuation known as the “reference value” which allows the non-market effects and consequences to be monetised.

However, an economic approach to road safety issues remains under-developed in France, even though it would open up prospects for the evaluation of public policies and provide a better understanding of the issues involved in economic calculations (Carnis and Mignot, 2012).

For a long time, the economics of road safety has therefore been reduced to a qualitative and quantitative assessment of the costs involved in road safety (Le Net, 1992; Boiteux et al., 1994; Quinet, 2000; Boiteux and Baumstark, 2001; Circulars and ministerial instructions including the one for 2019). With the exception of a few studies, most of which were carried out within Ifsttar (e.g. Jaeger, 1997; Carnis, 2001; Dahchour, 2002; Lahatte et al., 2007), most of the work on road safety economics carried out in France until recently has focused on counting the number of deaths and injuries and on valuing human life and injuries (serious or light) in order to integrate this dimension into profitability analyses for transport infrastructure. This is an approach in terms of econometric calculation applied in particular to the economic profitability of infrastructure projects (Mauritius and Crozet, 2007). Since 2017, the VASEM project (socio-economic valuation of road deaths - an Ifsttar project supported by the delegation for road safety) aims to improve knowledge of the cost of road deaths by studying new estimates of certain components of accident costs.

On these methodological bases, several economic analyses of road safety measures have been proposed. Economic analysis has therefore been used for the economic assessment of automated traffic regulation enforcement (Cameron and Delaney, 2010) or to lay the foundations for it in France (Carnis, 2010). This work compares the cost of deployment and the safety benefits but does not take into account the value of time lost by users. So although the impact of automated traffic regulation enforcement has been assessed in France (ONISR, 2006), it concerns only the impact in terms of accident research and does not aim at an overall economic assessment of the system.

Economic analysis is also used to evaluate in-vehicle systems, whether in France with the evaluation of the economic acceptability of the systems developed within the Sari project (automated road monitoring for driver and manager information) (Deregnaucourt, 2008), or in Germany with an evaluation and comparison of different in-vehicle driver assistance systems, such as electronic stability control or speed warning (Baum et al., 2010).

Furthermore, in the evaluation of the socio-economic impact of the ban on using telephones while driving (Ifsttar, Inserm, 2011), the authors show that in all the reference works, there are many uncertainties and biases and that the results must be taken with caution, while pointing out the importance of the choice of reference values selected that reflect the priorities given to an issue by the authorities.

In France, in 2018, the Ministry for Ecological and Inclusive Transition (MTES) assessed the effects of different scenarios for reducing the speed limit for light vehicles, and according to the type of network: motorway, urban, national, departmental, etc. (CGDD, 2018).

This work is based on an econometric analysis of the link between speed and accidents in France and on the use of the "MODEV"[7] traffic model developed by MTES. The positive effects of accident reduction are compared with the loss of travel time. The study shows that the socio-economic profitability of most of the scenarios tested is negative. **Only lowering the speed limit by 10km/h on the national and departmental road network of single two-way carriageways gives a positive balance of around €230 million, mainly due to the reduction in accidents.** The authors conclude that: “the insight provided by practical implementations nevertheless seems essential to better assess the robustness of these results”. It is within this framework that this report is presented.

[7]MODEV: National transport flow model

3 - Evaluation method

The purpose of assessing a public policy, according to French decree No. 98-1048 of 18 November 1998, is "to assess the effectiveness of this policy by comparing its results with the objectives assigned and the means used" (Blanchard et Carnis, 2015).

The evaluation method used is based on a detailed analysis to understand the effects of the measure with regard to four topics: speeds, accident rate, acceptability/acceptance and effects on society.

It sought to verify whether the objectives assigned to the measure were attained (detailed in part 1.2).

It had to take into account various imperatives in order to propose means of implementation that would respect the evaluation schedule: to have a report ready in July 2020.

The measure applies to the entire two-way road network without central separator in mainland France. It therefore concerns a type of network in its entirety and makes it difficult to compare with control sites not directly impacted by the measure. **The principle of an assessment "before" and "after" implementation of the measure on the network concerned was therefore adopted.** The rest of the French road network was selected as the control group, as detailed in section 3.2.6.

For the period "before" implementation of the measure, some topics were able to make use of existing historical data; for others these had to be reconstituted. As implementation was very rapid (less than 6 months after its decision), it was not possible, for reasons of cost and time, to completely reconstitute them. **A suitable acquisition system was therefore defined depending on the data concerned.** It is specified for each topic, bearing in mind that the "before" periods may be different for each one.

For the period "after" implementation of the measure, the Covid19 pandemic completely disrupted the mobilities of the first half of 2020. It prevented the collection of speed data in the early part of the year. **It was therefore decided in principle to carry out the evaluation over the 18 months following the implementation of the measure (July 2018 - December 2019).** When data were available for early 2020, these were provided.

Moreover, as mentioned in the *Context and objectives of the 80 km/h measure* section, the evaluation period since July 2018 has been marked by various phenomena (CISR measures implemented in January 2018, very strong media coverage of the 80 km/h issue, the "gilet jaune" social movement, etc.). As with any assessment, it is not possible to separate out what is specifically due to the lower speed limit. However, comparison with a control group, or reference to related data, was able to show changes related to the measure.

3.1 - Operating speeds: a purpose-designed observatory

There were no long-standing data on speeds in France to make a satisfactory reference for carrying out the assessment. This is because ONISR's national speed observatory delivers yearly aggregated indicators which does not allow break-up phenomenon to be highlighted or monthly monitoring of site-by-site indicators. Similarly, access to historical speed measurements delivered by traffic data acquisition systems did not appear to be suitable for several reasons: many people were involved, making it difficult to aggregate data, lack of a quality procedure, difficulty in qualifying suitable measurement sites, and a time constraint incompatible with the implementation of the VMA80 measure.

Cerema therefore set up a speed observatory to assess the impact of reducing the speed limit to 80 km/h on the speeds that drivers drive at (hereinafter the VMA80 observatory).

This VMA80 observatory had to meet different criteria:

- allow indicators to be monitored over time (at least 2 years),
- be able to distinguish between types of vehicles and road categories concerned,
- master the data acquisition chain to ensure the nature and quality of the data.

It comprises about forty measurement sites on two-way roads with two road lanes, spread over mainland France (illustration 5). They were selected for their neutrality in terms of infrastructure, i.e. so that road users can travel at the speed they want to.

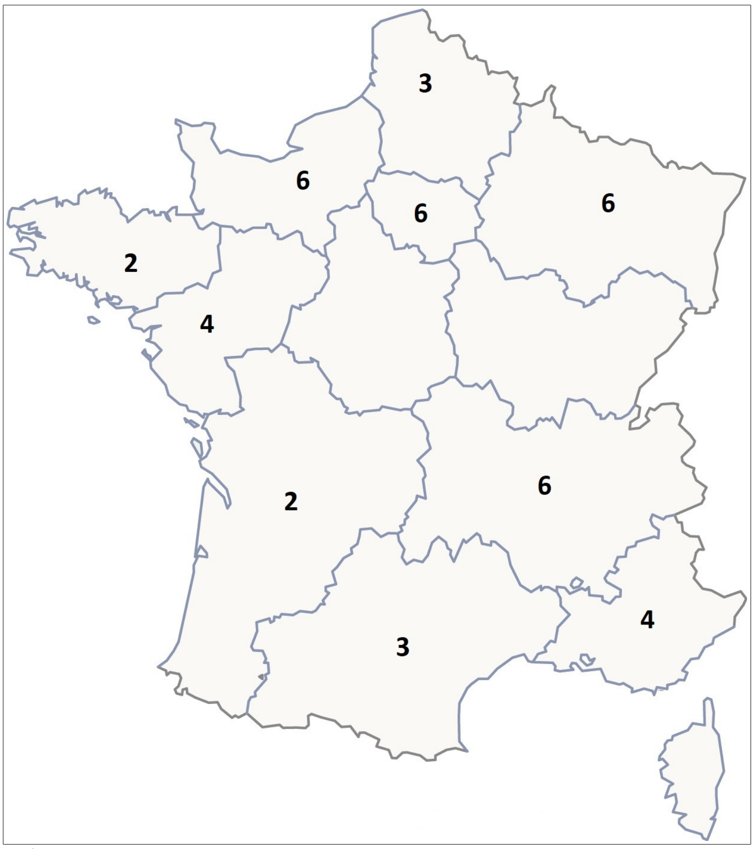


Illustration 5: Location map of the velocity observatory's measurement points according to French regions (source: Cerema)

The methodology adopted by Cerema aims to make to examine changes in driver behaviour. The observatory used does not claim to be representative of the operating speed on all French roads with a speed limit of 80 km/h. However, the technical choices made and the way the observatory is managed guarantee the quality of the measurements collected and the robustness of the indicators.

The observatory continuously collects speed data from all road users driving on the sites concerned. The observatory makes it possible to discriminate between light and heavy vehicles. It cannot identify powered two-wheelers (PTWs). However, when they are detected in the observatory, PTWs are assigned to the light vehicle category.

Time Headway (TH) is also recorded to identify vehicle interactions. Vehicles are said to be "free" when their speed is not impacted by the vehicle in front of them. Vehicles are “free” when the TH is greater than 5 seconds according to Aron and Durrande (2000) and OECD (2018). This allows different populations to be distinguished for the analysis of the indicators, including all vehicles, light vehicles, free light vehicles and HGVs.

The observatory does not use sampling. Regular checks are made to ensure the quality and continuity of the data collection. Because of this the measurement uncertainty of the average speed at each point is less than 1 %.

Indicators monitored over time (at least 2 years) are:

- average speed,
- the distribution of individual speeds and percentiles (V15 and V85);
  - speed V15 of light vehicles corresponds to the 15th percentile of the speed distribution and characterizes the speed of the slowest vehicles,
  - speed V85 corresponds to the 85th percentile and characterizes the speed of the fastest vehicles.
- the exceeding of speed thresholds with respect to the speed limit.

This observatory was started up in June 2018. The data obtained in June 2018 represent the period “before” the measure was implemented. Those from July 2018 to December 2019 represent the “after” period.

This short “before” time may be a limitation of the observatory used. Additional data sources were therefore sought to strengthen the analysis. For example, annual data from the ONISR observatory were used to confirm the trends in average speeds.

3.2 - Accident rate: essential methodological adjustments

3.2.1 - The BAAC: source of the data

The accident data come from the Road traffic accident and injury report (*Bulletin d’Analyses d’Accidents Corporels de la Circulation* - BAAC). These files are entered by the police for any traffic accident occurring on a road open to public traffic, involving at least one vehicle and resulting in at least one injured person. The file is consolidated by the local road safety observatories and ONISR with the support of Cerema.

After a long and detailed verification process, the data are validated and published by ONISR in the National Road Traffic Accident database. The validated data for 2018 have been official since May 29, 2019 and those for 2019 since May 15, 2020.

It is these official data that were used for this evaluation over the entire 2013-2019 period.

Data were processed using TRAxy, the new ONISR information system, and its analysis tool SAP-BI.

3.2.2 - Definition of the network “considered” by the assessment

Assessment of accident rate should concern the network affected by the measure in mainland France.

To do this, the scope of the study was defined according to the location characteristics in the BAAC, using the variables “outside urban areas” and “excluding motorways”. It concerns only the network in mainland France. An accident is taken into account under this network if at least one of the vehicles involved is travelling on a non-motorway road outside urban areas. For example, an accident at the intersection between a motorway ramp and a two-way road outside an urban area is taken into account.

Strictly speaking, this network should have been limited by excluding:

- sections where special speed limits are set: passing through localities outside urban areas, dangerous bends, approaches to urban areas at 70km/h or roundabouts, etc.;

This was not possible because the BAAC does not include the speed limits of the roads on which users were travelling. It is not possible to reconstitute them given the mass of accidents involved (1,915 deaths for the year 2017, for example and nearly 15,000 accidents per year).

- non-motorway dual carriageway sections.

Again, this could not be done. This is because it is not possible to reliably distinguish the traffic flow (one-way or two-way) or the number of lanes. Completion of these fields in the BAAC underwent a substantial change leading to a very significant improvement as of 2017 but not allowing comparison with previous years.

It is estimated that such sections account for 10% of the total network death rate.

Consequently, the network “outside urban areas” and “excluding motorways”, so defined, will be referred to as the **“considered network”**, as opposed to the rest of the road network in mainland France.

3.2.3 - A main indicator: the number of people killed

The main indicator of the assessment is the number of people killed on the considered network, which is certified by the French Public Statistics Authority (Autorité de la Statistique Publique - ASP).

Complementary indicators are also used:

- the number of injury accidents,
- the number of casualties.

These indicators will be used to calculate the death rate and casualty rate per 100 injury accidents.

It would have been useful to distinguish among the injured between those who are hospitalized (i.e. those who are hospitalized for more than 30 days) and those with minor injuries (those who are not hospitalized or hospitalized for less than 24 hours). This is particularly true for the socio-economic component.

This information is included in the BAAC, but since late 2016 and, for a reason that it has not yet been possible to clarify, the relative proportion of hospitalized injuries (HI) and minor injuries (MI) has changed abruptly and to such an extent that they cannot be explained by slow, moderate phenomena that might be put forward such as improved vehicle safety or a change in health policy. More likely this is due to changes in data capture or software interpretation.

This is why the HI and MI data are not certified by the ASP. This is also why also the 2017 HI/MI rate will be used as a reference for the socio-economic component.

3.2.4 - Choice of reference period 2013-2017

The choice of the period of reference years, which is to be used to calculate the average to which the data are compared “after” implementation of the measure, was made following an analysis of a long period of data since 2010.

It was a question of choosing a period:

- sufficiently long to be free from variations linked to the random nature of accident occurrence; conventionally, road safety studies take a minimum period of five years as a reference,
- which makes it possible to be free from any sudden trends that would affect the average.

To do this, the entire chronology of injury accidents and fatality data was examined over the period January 2010 to June 2018 (see illustration 6).

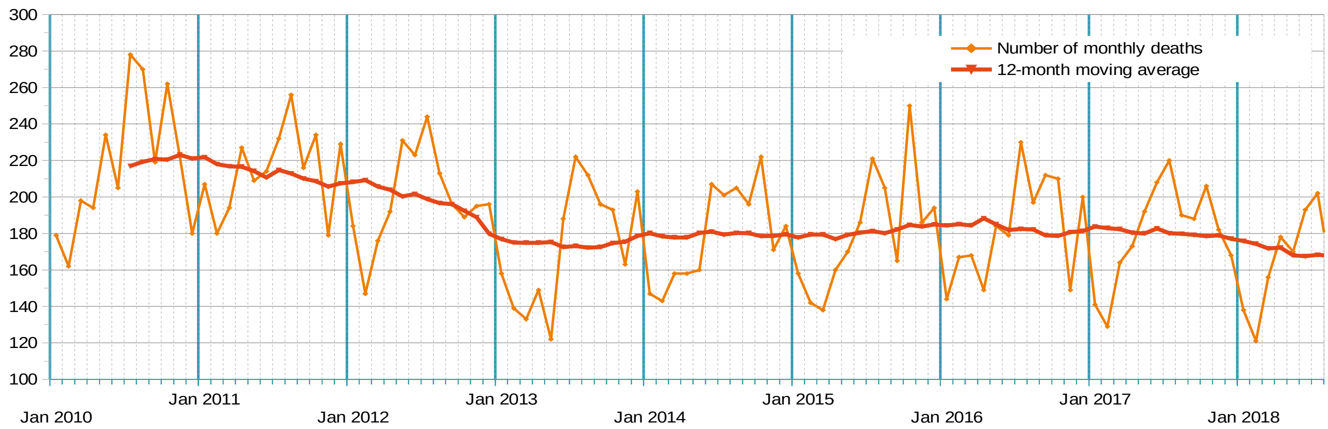


Illustration 6: Monthly data on the number of deaths from January 2010 to June 2018 on the considered network (Data source: official ONISR database)

The annual evolution of the number of deaths on the considered network, illustrated by the moving average of the last twelve months for a given month, shows a decrease from 2010 to 2013, followed by stagnation or even a slight increase until late 2017. The period 2013-2017 therefore appears to be stable and uninterrupted in terms of the number of deaths on the considered network. There is no risk of introducing a phenomenon of regression towards the average in the assessment of the period “after” the measure was implemented.

The period 2013-2017 was therefore chosen as the reference period “before” implementation of the measure for the accident analysis.

3.2.5 - Seasonal adjustment of accident data to make them comparable

Examination of accident data curves (e.g., illustration 6) shows that they are affected by a seasonality phenomenon: regularly returning peaks show that some months are regularly more accident-causing than others. More generally, the second half of the year is more unfavourable in terms of the accident record than the first half of the year.

It also shows that seasonality is compensated for over a full year.

If it is desired to make a valid comparison of data, therefore:

- either one month of data is compared with identical months from several previous years (ditto for a given quarter or half-year),
- or a multiple period of twelve months is compared with another multiple period of twelve months. This is because any multiple period of twelve months includes all the months of the year.

On the other hand, comparing one month with the previous month does not teach us anything. Similarly, comparing one month with a different month in a previous year, or comparing a first half-year with a second half-year is meaningless.

Assessment of the 80 km/h measure is based on the comparison of the 18 months following its implementation (July 2018 - December 2019) with the reference period 2013-2017, as explained in the introduction to this chapter. The assessment period therefore consists of two second half-years and only one first half-year. It is not possible, as explained above, to simply sum these semesters in order to compare them to a reference.

A method called seasonal adjustment must be used. This consists of correcting the data to make them comparable (see the full explanation in the appendix 5).

The principle of seasonal adjustment involves interpreting the time series as a phenomenon resulting from the composition of several phenomena:

- A **trend component**. This is a long-term effect, resulting from all the permanent effects to which the series is subject. This is to simplify the average behaviour of the series.

For assessing the 80 km/h measure, the trend adopted is the 12-month moving central average, devoid of seasonality,

- A **seasonal** or cyclical **component**. These are effects that recur over time at a fixed period. There may be several seasonal effects, each with its own period,

- A **residual component**, reflecting random effects.

An additive seasonal adjustment was chosen here, which has the advantage of keeping strictly by construction the sums of months equal to the 12-month period, e.g. the annual appraisals. This decomposition can be summarized by:

$$X_m = ZX_m + SX_m + rX_m$$

where: X_m (Acc, Killed, Severely injured, Slightly injured) is the value of the variable in month m

Zx_m is the trend in month m

SX_m is the seasonal coefficient in month m

rX_m is the residual component at month m

Seasonal adjustment makes it possible to analyse, describe and explain the chronology of events that occurred in the past, without being troubled by seasonal hazards.

3.2.6 - Assessment of the impact of the measure on the accident rate: calculating the odds ratio

To estimate the number of lives saved that can be put down to the measure, this comparison must take into account various factors including regression to the mean, long-term trends and exogenous changes such as traffic trends. Calculating the odds ratio allows these factors to be taken into account (Hauer, 1997).

The analysis of the monthly accident data (illustration 6) showed that the selected reference period was stable and uninterrupted and was not likely to introduce regression towards the mean in the assessment.

For the definition of the control group, the 80 km/h measurement applies to the entire two-way road network without a central separator in mainland France. It therefore concerns a type of network in its entirety and makes it difficult to compare with control groups not directly impacted by the measure. It was therefore decided to use the **mainland France "rest of the network" scope, excluding the considered network, as the control group.** This principle has already been used in before-and-after project comparisons to estimate the impact on road safety (Elvik et al., 2017).

Moreover, it is not possible to have detailed knowledge of the traffic on the considered network. The data does not exist in a complete and reliable manner. Permanent counts exist on some networks. However these are not exhaustive and as they are managed by different authorities (State, departmental councils, etc.), the data collection systems are disparate, making them impossible to aggregate. In addition, given the size of the network affected (over 400,000 km), it was not possible to carry out occasional counts to reconstruct the data.

The comparison between the considered network and the control group can be made using the following formula, which provides an approach to the estimated impact of the measure.

Given that (Hauer, 1997; Elvik et al., 2017):

- K = number of deaths before measurement on the considered network
- L = number of deaths after measurement on the considered network
- M = number of deaths before measurement on the rest of the network (control group)
- N = number of deaths after measurement on the rest of the network (control group)
- w = (N/M) x K

The odds ratio is given by the formula: Odds ratio (OR) =[(L/K)/(N/M)] / (1 + 1/K + 1/M+ 1/N)

And the estimated error by E = (OR) x $\sqrt{\left(\frac{1}{K}+\frac{1}{w}+\frac{1}{M}+\frac{1}{N}\right)/\left(1+\frac{1}{w}\right)}$

The calculation of the odds ratio gives the percentage change in the accident rate on the considered network compared to the rest of the network in mainland France.

3.3 - Acceptability / Acceptance of the measure thanks to surveys

As stated in 2.3, acceptability refers to the study of a public policy before it is put in place, while acceptance refers to the perception of that public policy once it is effective, once users have been confronted with it.

The objective of this section is therefore to analyse the acceptability and the acceptance of the measure by users according to the different dimensions examined and according to the characteristics of the respondents: main means of transport, age groups, socio-professional categories and residential environments (urban, rural, semi-urban, etc.). It also involves examining how this acceptance has changed during the two years of the assessment.

To do this, a questionnaire was sent out by a survey institute to a large sample of drivers representative of the French people. It includes the different dimensions of the acceptability/acceptance of the measure, in particular its perceived effectiveness and usefulness, its fairness, its impact on the behaviour and the general attitude of the respondents.

Three waves of surveys were carried out over the study period:

- from April 24 to May 2, 2018, i.e. “before” implementation of the measure, with 5,310 respondents aged 18 and over (wave 1)
- “after” implementation of the measure:
    - from March 7 to 14, 2019, with 3,797 respondents aged 18 and over (wave 2),
    - from October 10 to 17, 2019, with 3,884 respondents aged 18 and over (wave 3).

The 1st wave of the survey aimed to study “acceptability”; the 2nd and 3rd waves its “acceptance”.

The panel of respondents was chosen to be representative of French people and to be comparable between surveys. It is 47% male, with an average age of 47 for the first two waves and 49 for the third. The main means of transport used by respondents on the considered network in the last 6 months is the car. Nearly a quarter of the sample lives in a rural area (23%) and 18 % in a town with less than 20,000 inhabitants. Appendix9 gives the main characteristics of these panels.

Bias could come from the fact that respondents are not the same from one wave to the next. Ensuring that the samples are representative according to certain variables as described above provides an initial response. However, it is impossible to exhaustively define all the variables that characterize a sample. The very large sample sizes neutralize this bias.

Even though the questionnaire is constructed according to a scientific protocol based on the scientific literature, biases inherent to any public policy may remain, especially when it is highly publicized. Social movements that occurred during the analysis period and the sometimes contradictory information disseminated by the media about the measure may therefore have influenced the respondents. Similarly, allowing departments to put certain sections back to 90 km/h may have introduced confusion.

3.4 - Analysis of effects on society based on the transport project assessment reference framework

The purpose of this section is to understand the effects on society related to the measure of lowering the speed limit to 80 km/h on two-way roads without a central separator. It draws heavily on the previous sections.

The speed reduction measure is not a transport project in the strict sense of the term, but its assessment can be based on the general framework for the assessment of transport projects, as presented in the government instruction of 16 June 2014. This principle was proposed by the French Council of State.

The *ex-ante* assessment conducted by the CGDD (2018) also falls within the MTES (Ministry for Ecological and Inclusive Transition) reference framework for the evaluation of transport projects.

3.4.1 - Analysis of multiple effects: accidents, travel time, environment, acceptability

The assessment of transport projects is compulsory in France. When this assessment work is conducted prior to the decision to carry out the project, the socio-economic assessment is used to determine whether it is appropriate to carry out the project. When conducted after a project is commissioned, socio-economic assessment provides a measure of the attainment of objectives and potential discrepancies. Before and after socio-economic assessment is therefore an important tool for public decision-making and transparency of public action.

The assessment of the 80 km/h measurement is atypical in relation to the reference frame. This is because the aim is not to analyse the foreseeable effects of this measure (ex-ante assessment), nor to compare and explain the differences between the expected and observed effects (ex-post assessment), but to analyse the effects observed after its implementation and to measure the attainment of the main objectives (in-itinere assessment).

This assessment is based on measured data. It is based on the qualitative and quantitative analyses of the effects of lowering the speed limit to 80 km/h and the socio-economic calculation.

Specifically, the following effects are to be developed:

- A quantitative analysis of the accident rate;
- A quantitative analysis of travel times;
- An analysis of air and noise pollution;
- An analysis of user acceptability.

The technical note of 27 June 2014, drawn up by the Directorate General for Transport Infrastructures and the Sea, specifies that the assessment is part of a progressive process that helps in the development of the project and brings its foreseeable effects to the attention of those concerned. The analysis of the effects of the project is therefore adapted to the phase in which the assessment is carried out. In this sense, the principles of progressiveness and proportionality guide this assessment:

- proportionality principle: the level of precision of the assessment depends on the importance of the issues and objectives, the scale of the project and its possible effects;
- progressiveness principle: the level of assessment depends on the progress of the project and the level of knowledge that results from it.

3.4.2 - Socio-economic calculation based on a 2017 / 2019 comparison

In application of the French evaluation reference framework for transport projects, a global socio-economic calculation is carried out to identify and compare the expected advantages and the resulting disadvantages.

With regard to the literature (see section 2) and the regulatory framework of the reference framework, the quantified parameters are as follows:

- Gains in road safety, linked to a reduction in the number of accidents,
- Losses due to longer travel times,
- Gains related to lower fuel consumption and GHG emissions,
- Losses related to the investment cost of the measure.

This socio-economic calculation is made by comparing the full years 2017 (“before” implementation of the measure) and 2019 (“after” implementation).

Certain methodological imperatives were taken into account in this calculation, such as the difficulty in specifying the length of the network affected by the measure. It is estimated at about 400,000 kilometres, but it is not possible to have an exact figure. The imperatives are detailed in the corresponding chapters.

The traffic data are not known in a detailed and exhaustive way. They are not available for all networks and departments in France, which makes it difficult to know the volume of vehicles per km on the network concerned. A low and high traffic volume estimate was therefore proposed.

4 - Speeds

The results presented in this section concern the two-way, two-lane roads of the VMA80 observatory. They are drawn up from **143 million passing vehicles** measured from June 1 2018 to December 31, 2019. The period “before” implementation of the measure is June 2018, the period “after” is July 2018 to December 2019 (i.e. 18 months). The detailed figures and overall results of the Observatory are presented in Appendix 1.

It should be remembered that the Observatory does not use sampling. Regular checks are made to ensure the quality and continuity of the data collection. Because of this the measurement uncertainty of the average speed at each point is less than 1 %.

4.1 - Changes in speeds for all vehicles

4.1.1 - A break recorded at July 1, 2018

The results show, **as of Sunday 1 July 2018, a break in speed trends on the VMA80 observatory's two-lane two-way roads,** as shown by the average daily speed trend for all vehicles (illustration 7).

The average speed in July 2018 is 4.3 km/h lower than in June 2018 for all vehicles.

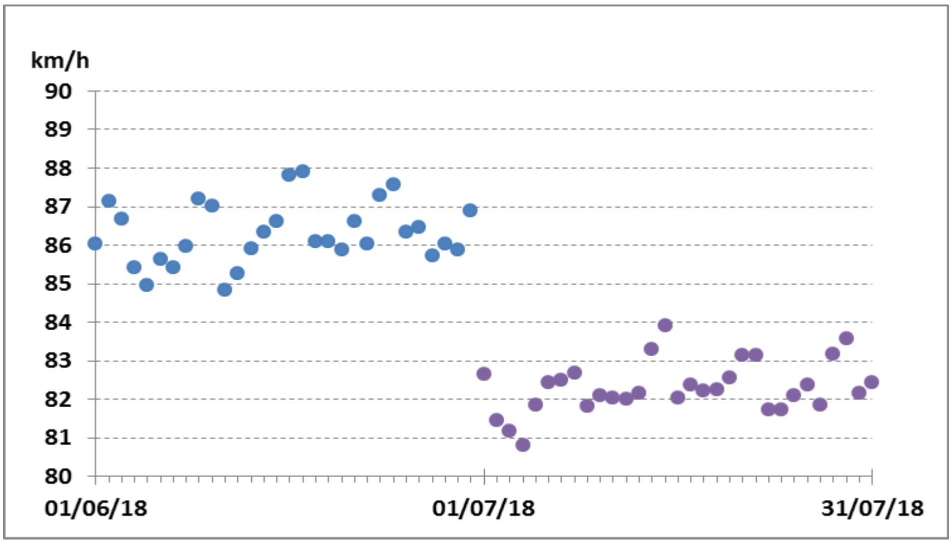


Illustration 7: Changing average daily speeds of all vehicles during the months of June and July 2018; data collected by the VMA80 observatory (Source: Cerema)

Note that the variability of the mean daily speeds in illustration 7 is due to the difference between weekdays and weekends.

4.1.2 - A drop in average monthly speeds

In the 18 months following implementation of the measure, the monthly change in speeds for all road users fell greatly in July 2018, with a slight increase until June 2019; they then remain stable or even fall slightly (illustration 8). This trend had been observed in the experiment conducted between 2015 and 2017 (Cerema, 2017).

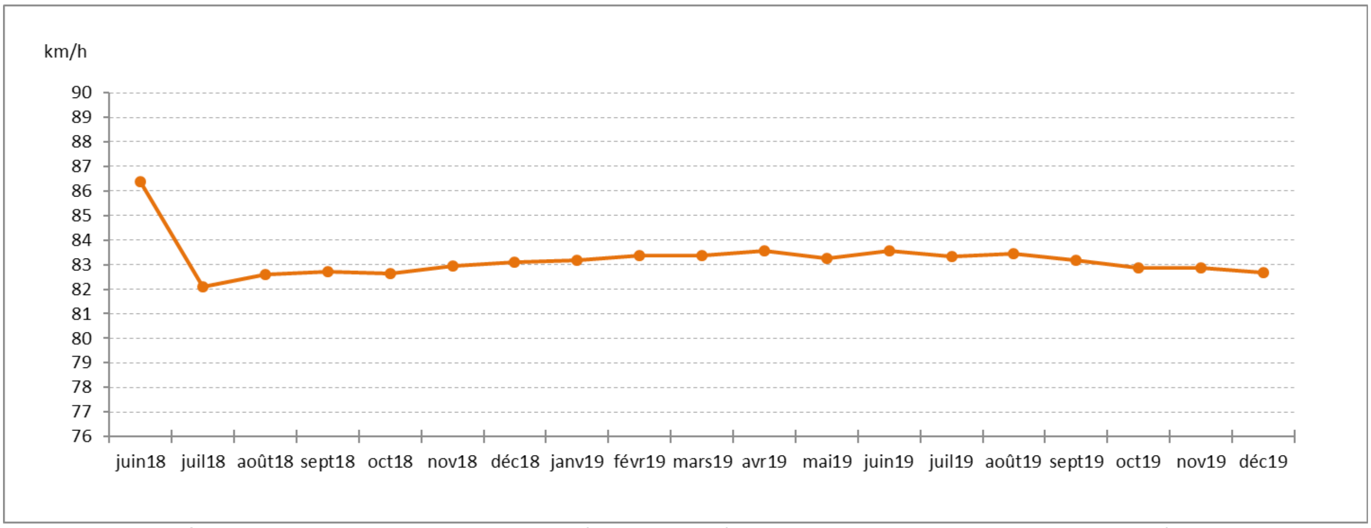


Illustration 8: Change in average monthly speeds of all vehicles from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

The drop in the average speed of all vehicles over the 18-month period after implementation of the measure **is 3.3 km/h** compared to June 2018. The average speed was 86.4 km/h before implementation (June 2018) and 83.1 km/h after implementation (July 2018 to December 2019). In the "after" period, the average speed in the second half of 2018 was 82.7 km/h, 83.4 km/h in the first half of 2019 and 83.1 km/h in the second half of 2019.

Note that any difference in average monthly speed of 0.1 km/h is statistically significant according to the Student Test (p = 0.05)[8].

The decrease in speeds corresponds overall to the effect expected if we refer to the international literature (-3 km/h according to Elvik, 2012; OECD, 2018). It is, however, less pronounced than those put forward by the CNSR committee of experts (-4 km/h or even -5 km/h, in the context of efficient traffic regulation enforcement according to CNSR, 2013) and the results of the experiment conducted in France from 2015 to 2017 (-4.7 km/h for light vehicles according to Cerema, 2017).

4.1.3 - A table difference between the slowest and highest speeds

Changes in average speed may be accompanied by changes in the difference between vehicle speeds, particularly between the fastest and slowest vehicles. To verify this, the difference between the 85th percentile (V85) and the 15th percentile (V15) of the speeds was examined.

[8] The distribution of velocities is similar to a normal law.

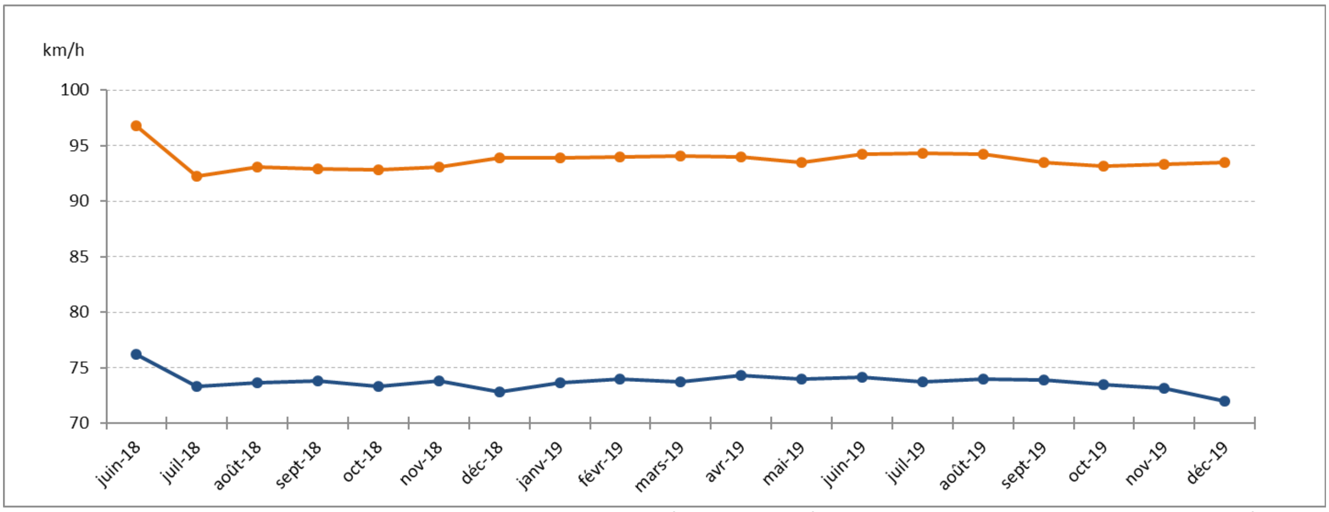


Illustration 9: V15 (shown in blue) and V85 (shown in orange) of all vehicles from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Lowering the speed limit to 80 km/h had the effect of reducing the V15 of the speed distribution of all vehicles by 2.4 km/h averaged over the entire period from July 2018 to December 2019 compared to June 2018.

The same influence is observed for the V85 (a 3.5 km/h drop).

The difference between V15 and V85 varies by only 1 km/h between June 2018 and the average for the period after the measurement (21 km/h and 20 km/h respectively). This result suggests that, overall, the measure had virtually no impact on the speed dispersion of all vehicles.

Overall it appears that the difference between the speeds of the slowest vehicles (characterised by V15) and the fastest vehicles (characterised by V85) has hardly changed with the implementation of the measure.

There has therefore been an overall decrease in all speeds, including the highest.

4.2 - Changes in speeds for light vehicles

4.2.1 - A drop in average monthly speeds

The monthly change in the average speed of light vehicles follows the same trend as that of all users. (illustration 10).

The drop in the average speed of light vehicles over the 18-month period after implementation of the measure **is 3.5 km/h** compared to June 2018. The average speed was 87.0 km/h before implementation (June 2018) and 83.5 km/h after implementation (July 2018 to December 2019). In the “after” period, the average speed in the second half of 2018 was 83.1 km/h, in the first half of 2019, 83.9 km/h and in the second half of 2019, 83.5 km/h.

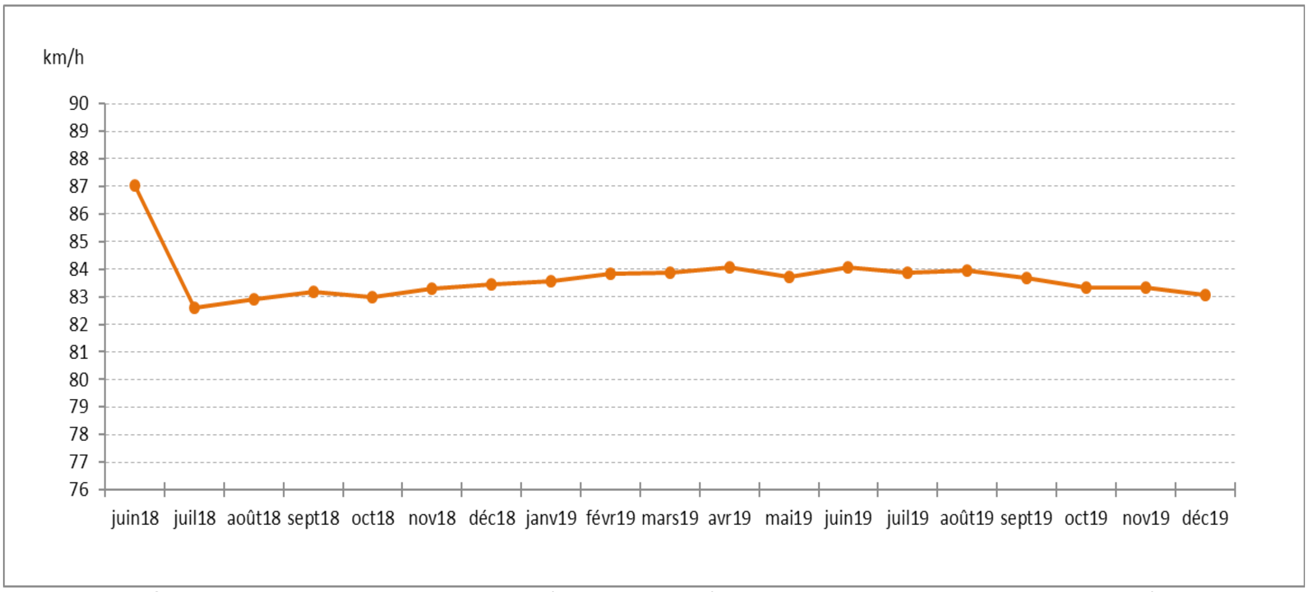


Illustration 10: Change in average monthly speeds of light vehicles from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

In addition, the monthly average speed reduction for free light vehicles[9] was 3.6 km/h in December 2019 compared to June 2018. The result of this indicator, less sensitive to the effects of traffic, confirms a favourable change in the behaviour of light vehicle drivers.

To confirm this downward trend, data from the ONISR observatory[10] can be viewed. ONISR publishes annual indicators on speeds, distinguishing several types of road infrastructure and categories of users. Considering the daytime speeds of passenger vehicles on 2- and 3-lane roads outside urban areas, a difference in average daytime speeds of 4.4 km/h between 2017 and 2019 can be seen.

Although the two observatories do not use the same measurement tools, are not set on the same perimeters and periods, **both reveal a downward trend in speeds after implementation of the measure.**

4.2.2 - A decrease in all speeds, including the highest

Illustration 11 shows the changing speed distribution on two-way, two-lane roads of the VMA80 observatory. It can be seen that after the measure was implemented speed distribution was completely translated to lower speeds. **The drop in speed therefore concerns the entire distribution of light vehicle speeds.**

[9] Vehicles are said to be "free" when their speed is not impacted by the vehicle in front. The parameter used is Time Headway (TH). Vehicles are “free” when the TH is greater than 5 seconds according to Aron and Durrande (2000) and OECD (2018).

[10] https://www.onisr.securite-routiere.gouv.fr/etudes-et-recherches/comportements-en-circulation/observations/observatoire-des-vitesses

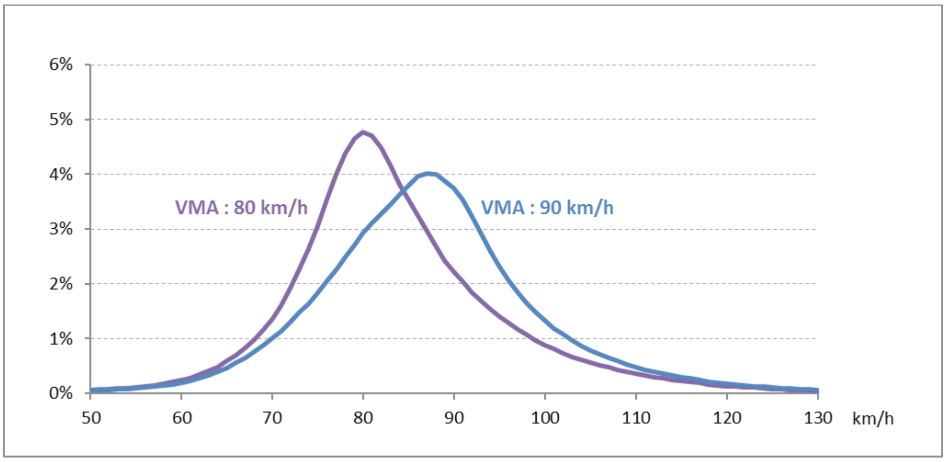


Illustration 11: Comparison of the mean speed distribution of light vehicles from July 2018 to December 2019 (speed limit: 80 km/h) compared to June 2018 (speed limit: 90 km/h), data from the VMA80 observatory (Source: Cerema)

Speed measurements taken up to December 2019 show that there is no tightening of the speed curve: the difference between the slowest and fastest speeds remains the same.

4.2.3 - More limited impact on speeds between 80 and 90 km/h

The decrease in speed of light vehicles is more relevant to the 90-100 km/h and >100 km/h classes than to the 80-90 km/h class (illustration 12).

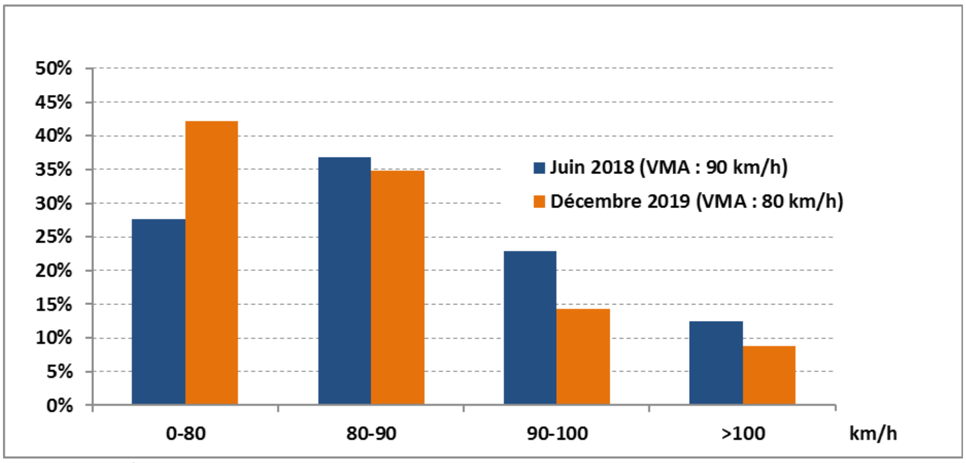


Illustration 12: Comparison of light vehicle speed distribution: December 2019 (speed limit: 80 km/h) compared to June 2018 (speed limit: 90 km/h), data from the VMA80 observatory (Source: Cerema)

So **in December 2019, 58% of drivers are still driving above 80 km/h**, 35% of drivers are driving between 80 and 90 km/h and 23% are driving over 90 km/h.

In December 2019, 58% of drivers of light vehicles were driving above the maximum speed limit (80 km/h), with 35% of them not complying with the speed limit before the measure was implemented (with a speed limit of 90 km/h).

This high proportion of light vehicles travelling at higher speeds higher than the limit may affect the impact of the measure in terms of accidents, as research (Taylor and al. 2000; Kloeden et al. 2002; Brenac et al. 2016) has shown that drivers driving faster than the average speed have a higher risk of being involved in a crash, and that speeding below 10 km/h played an important role in road deaths (Viallon and Laumon, 2013).

The insufficiently changed behaviour of some drivers means that the measure cannot reach its full potential. If all the vehicles recorded by the VMA80 observatory were to travel at a speed of 80 km/h or less, the drop in average speed would be three times greater in December 2019, i.e. 9.7 km/h instead of 3.5 km/h.

Although the proportion of drivers of light vehicles travelling at over 100 km/h decreased after the measure, it was still 9% in December 2019 (compared to 13% before the speed limit was lowered to 80 km/h in June 2018).

4.2.4 - Unchanged interaction between light vehicles

Time headway (TH) is an indicator that characterises, in part, the nature of interactions between vehicles.

TH is considered short when it is less than 2 seconds (article R412-12 of the French highway code). The time of 2 seconds is generally accepted as the average value of the reaction time required to react to a situation (SWOW, 2012). THs of less than 2 seconds accounted for 25% of THs before the measure was implemented and accounted for the same proportion after it was implemented.

TH is considered very short when it is less than 1 second. These values correspond more to situations in which the vehicle in front is put under pressurise or even aggressive driving (Hany et al., 2017). THs of less than 1 second accounted for 7% of THs before the measure was implemented and the same proportion after it was implemented.

Light vehicles therefore keep the same proportion of time difference with regard to the previous vehicle. There are not more driving situations with short and very short THs observed after implementation of the measure.

4.3 - Changes in speeds for heavy goods vehicles

4.3.1 - A drop in average monthly speeds

The measure to lower the speed limit does not concern HGVs (excluding coaches), since their speed was already limited to 80 km/h before July 2018. Nevertheless, **a decrease in the average speed of heavy goods vehicles of 1,8 km/h** is observed over the 18-month period after the measure was implemented compared to June 2018 (illustration 13).

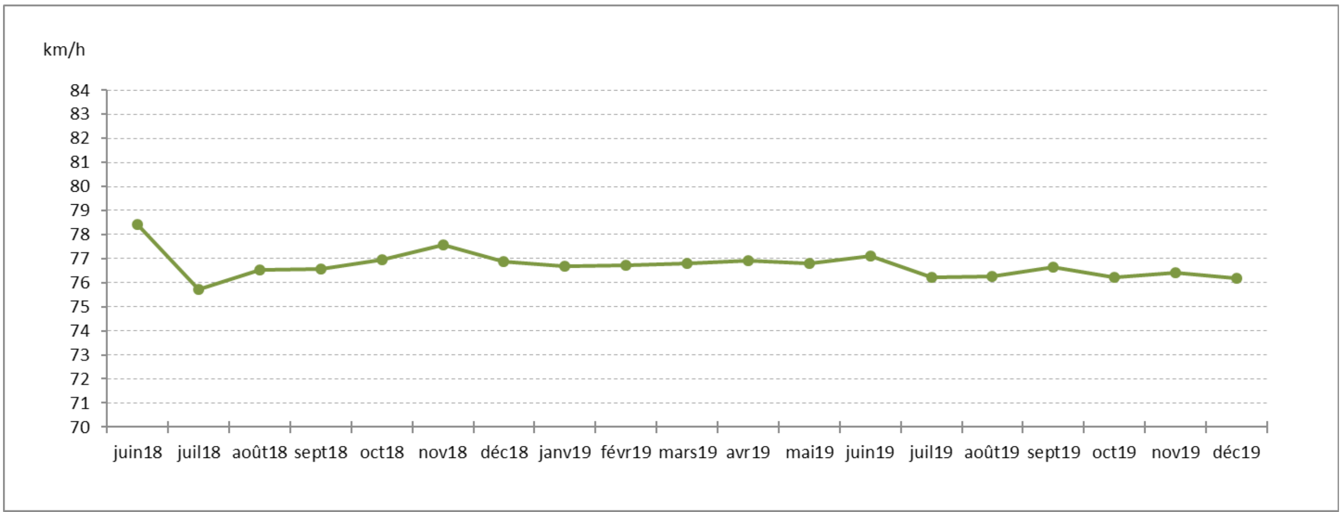


Illustration 13: Change in average monthly speeds of HGVs from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

4.3.2 - Improved compliance with the speed limit by HGVs

The VMA80 observatory shows the changes in the rates of speeding by HGVs from June 2018 to December 2019. The HGV infringement rate is 11 points lower in December 2019 than in June 2018, falling from 49% to 38%.

It appears that, firstly, **heavy goods vehicles have significantly reduced their speed and, secondly, that they now better observe the 80 km/h speed limit.**

4.3.3 - Unchanged time difference with other vehicles

In terms of interaction with other road users, HGVs maintain the same proportionate time gap from the preceding vehicle. **They do not drive any closer to the vehicle in front of them.**

Short and very short Time headway remain stable after implementation of the measure (6% for THs of less than 2 seconds, said to be short, and 1% for THs of less than 1 second, said to be very short).

4.4 - No impact on vehicle platoons

The analysis of vehicle platoons makes it possible to check the impact on traffic flow.

A vehicle can be considered as belonging to a platoon when its TH with the preceding and/or following vehicle is less than or equal to 3 seconds (Al-Kaisy and Durbin, 2011). The analysis was carried out on a comparison of June 2019 with June 2018 in order to minimise traffic and usage effects to which the indicators might be sensitive. The VMA80 observatory gives similar traffic values in June 2018 and June 2019, both in terms of average daily traffic (around 7,700 vehicles/day) and in terms of the proportion of HGVs (around 5%).

Platoons	June 2018	June 2019
Proportion of vehicles in a platoon	49.8%	51.2%
Average number of vehicles in a platoon	3	3
Proportion of HGVs in the platoons	3.5%	3.4%
Proportion of HGVs at the head of the platoons	2.3%	2.2%
Proportion of HGVs in second place and light vehicles at the head	0.4%	0,5%

Table 3 Composition of vehicle packs in June 2018 and 2019, data from the VMA80 observatory (Source: Cerema)

The indicators in table *3* show that lowering the speed limit to 80 km/h had no significant impact on platoon formation in June 2019 compared to June 2018. The proportion of vehicles (light vehicles and HGVs) travelling in a platoon remains practically identical for the two months analysed. Similarly, the average number of vehicles per platoon did not change. For platoons with at least one HGV, there is no noticeable difference between, firstly, when the HGV is the first vehicle in the platoon and, secondly, when the HGV immediately follows a leading light vehicle.

This analysis shows that the measure had no impact on the formation of vehicle platoons. Most of these platoons are made up exclusively of light vehicles.

By combining the various indicators in table 3, an analysis was made of the platoons led by a light vehicle and closely followed by an HGV. The vast majority of vehicle platoons are made up exclusively of light vehicles (leading and follower vehicles). Platoons starting with an HGV are much less frequent and platoons starting with a light vehicle followed immediately by an HGV remain rare occurrences.

%o LVs at the head of the platoon and respecting the speed limit	June 2018 (speed limit: 90 km/h)	June 2019 (speed limit: 80 km/h)
HGV following < 2 s	0.07%	0.05%
HGV following < 1 s	0.007%	0.004%

Table 4 Proportion of LVs respecting the speed limit at the head of a pack and followed too closely by an HGV in June 2018 and 2019, data from the VMA80 observatory (Source: Cerema)

The table describes the situations of platoons formed by a light vehicle in the lead respecting the speed limit and followed by an HGV with a short or very short TH. Before and after the VMA80 measure, these driving situations are very rare.

Table 4 also shows that the measure did not increase the proportion of light vehicles subjected to a short TH by a following HGV when the light vehicle respects the speed limit at the head of a platoon.

A light vehicle at the head of the platoon and followed by an HGV has no more pressure on it when respecting the 80 km/h speed limit than it had when respecting the 90 km/h speed limit.

5 - Accident rate

All raw data are presented in appendix 4 and seasonally adjusted data in appendix 5.

This chapter discusses confidence intervals, the details of which are discussed in appendix 6. For example, “significant” or “insignificant” deviations will regularly be discussed. This term means that the value in question is outside the confidence interval of the mathematical expectation of Poisson's law - the statistical law of accident occurrence and rate. The upper and lower limits of these intervals are given in table 49 of appendix 6 for each of the variables considered. Deviations from the 99% confidence interval values are considered to be highly significant; those from the 95% confidence interval values are considered to be significant.

5.1 - Impact of the measure on the number of deaths

5.1.1 - Significant gains each half year

Assessment of the measure covers 18 months. This period includes the second half of 2018, the first half of 2019 and the second half of 2019.

As explained in part 3.2.5, it is not possible to compare or add the first and second semesters because of seasonal variations. The effects of the measure are therefore looked at, in relation to the reference period, for each type of half-year taken separately (illustration 14).

First of all, it appears that the situation is stable between the second halves of 2018 and 2019, both on the considered network and on the rest of the network.

On the considered network, the drop in the number of deaths is very significant:

- for the first half of 2019, the decrease in the number of deaths compared to the average for the first quarters of the reference period is 76 deaths, i.e. 8%, and is very significant[11]
- for the second halves of 2018 and 2019, the decrease represents 125 and 130 deaths respectively, i.e. 10% and is very significant[12].

In contrast, on the rest of the network, the change is more unfavourable:

- the first half of 2019 saw an increase of 52 deaths, i.e. 9% compared to the reference period. This increase is very significant[13],
- the second half-years are simply a continuation of the reference period: the differences are not significant.

[11]the observed value of 887 deaths is well below the 928 deaths at the lower bound of the 99% confidence interval of Poisson's Law expectation

[12]for the second halves of 2018 and 2019 (1,063 and 1,058 deaths respectively), the values are also well below the lower bound of the 99% confidence interval (1,149 deaths)

[13]the value of 631 deaths is much higher than the 607 deaths that constitute the upper bound of the 99% confidence interval.

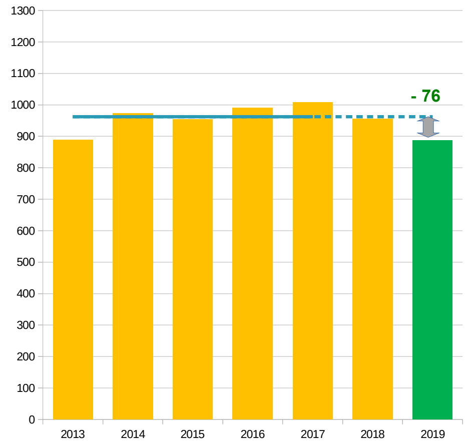
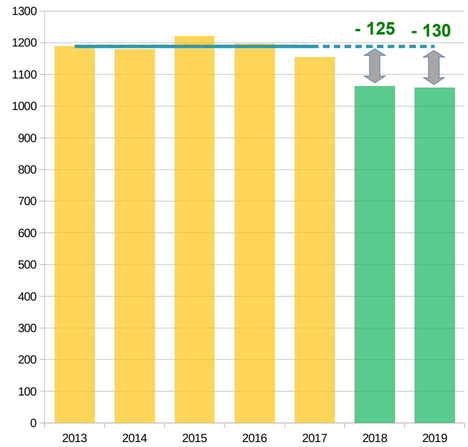
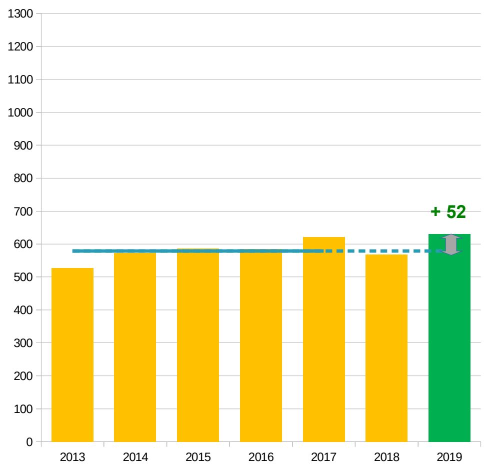
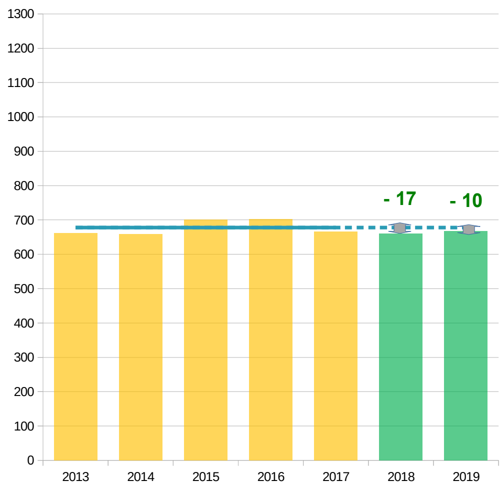
<table>
<tr><th></th><th>First half-years</th><th>Seconds half-years</th></tr>
<tr><td>Considered network</td><td>
</td><td>
</td></tr>
<tr><td>Rest of the network</td><td>
</td><td>
</td></tr>
</table>

Illustration 14: Comparison of the number of deaths per six-month period, by type of network - the considered network and the rest of the network - between the "before" period from 2013 to 2017 and the "after" period from July 2018 to December 2019 (Source: Official BAAC)

On the considered network, therefore, each half-year shows significant and very significant decreases in the number of deaths compared to the average of previous half-years.

Conversely, on the rest of the network, no gains were recorded in the second half of the year, and the first half of 2019 even shows a significant and very significant increase in the number of deaths.

5.1.2 - Historic number of lives saved in 2019

Working on the annual road safety appraisals makes it possible to analyse the gross fatality figures. In this approach, it is not possible to fully identify the influence of the implementation of the measure, as the year 2018 is considered as a whole. This aspect will be dealt with in the next section. However, it is interesting to observe the trends.

On the considered network (illustration 15), the observed decreases from the baseline average of 132 fewer deaths for the full year 2018 and 206 fewer for the full year 2019 are statistically highly significant[14]. As seen in part 3.2.4, they cannot be attributed to a random variation around the average insofar as the reference period is stable.

This result is not found in at all on the rest of the network (illustration 16), where the trend is for an increase of 28 deaths for the whole year 2018 and 42 deaths for the year 2019. These fluctuations, which overall lead to a very slight increase compared to the average observed in 2013-2017, are not statistically significant.[15].

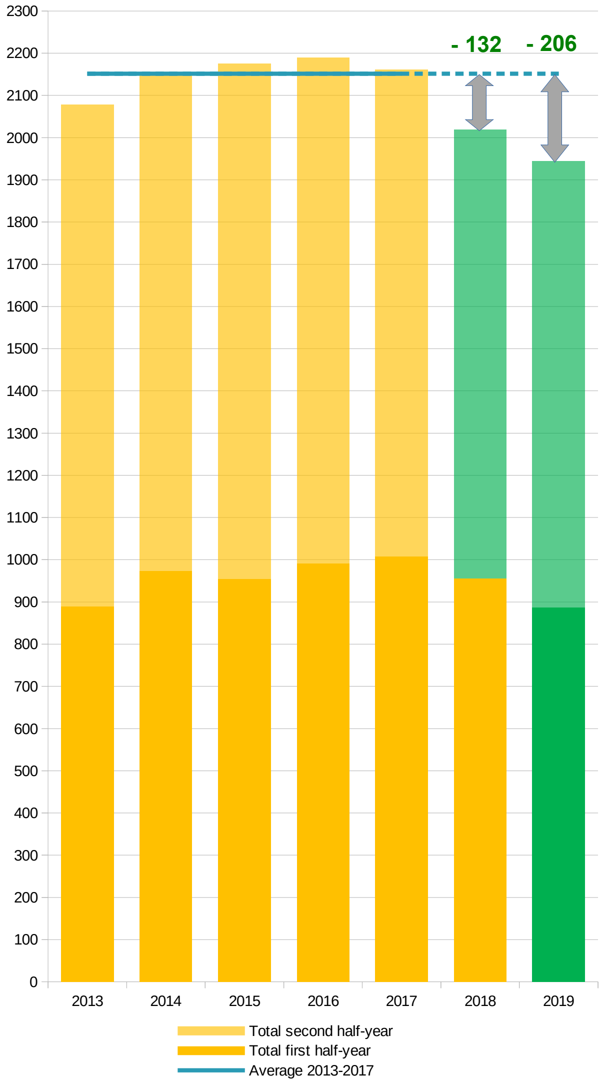


Illustration 15 - Comparison of the number of deaths on the considered network, by year (Sources: Official BAAC)

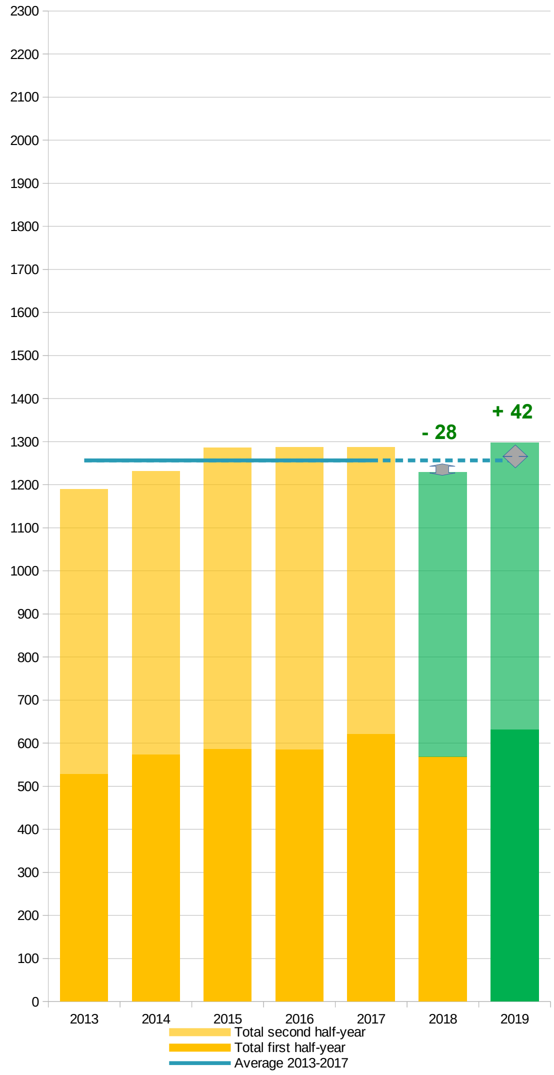


Illustration 16 - Comparison of the number of deaths on the rest of the network, by year (Sources: Official BAAC)

[14]The 2018 value of 2,019 deaths and the 2019 value of 1,945 deaths are well below the lower bound of this 99% confidence interval (2,098).

[15]The 1,229 deaths in 2018 fall within the 95% confidence interval of the reference mean Poisson's Law. The 1,299 deaths in 2019 are at the upper bound of the 99% range.

The year 2019, with 1,945 deaths, appears to be the year with the lowest number of deaths ever on the considered network. This value is statistically lower than the 2013 results (which saw 2,078 deaths).

In contrast, on the rest of the network, the number of deaths remains at the same level as in 2017 and exceeds that of 2013.

5.1.3 - After 18 months, continuous improvement on the considered network; no change on the rest of the network

While the half-yearly approaches above, like the rolling year approaches, allow seasonal variations to be overcome, this is not the case with the 18-month approach. This is because the period comprises a single first half year (2019) for two second half years (2018 and 2019).

The overall 18-month approach can therefore only be undertaken after seasonal adjustment of the monthly values: the data used here are the previously seasonally adjusted data (see appendix 5 for details).

First, the cumulative sums of seasonally adjusted data over 18 rolling months are compared between July 2014 (the sum from January 2013 to June 2014) and December 2019.

For this purpose, the comparison is made by taking as base 100 the values of the corresponding 18 months of the reference periods 2013-2017 for each of the networks taken separately, namely K and M in Table 5:

		2nd half-year 2013-2017	Average year 2013-2017	Total reference period
Considered network	*K*	1087.5	2151.0	3238.5
Rest of network	*M*	635.9	1256.6	1892.5

Table 5 - Seasonally adjusted average data of the reference number of deaths for a period of 18 months, based on SA data for the period 2013-2017

The graph comparing the two networks (Illustration 17) confirms the trend seen in the half-yearly approach, this time accurate to one month.

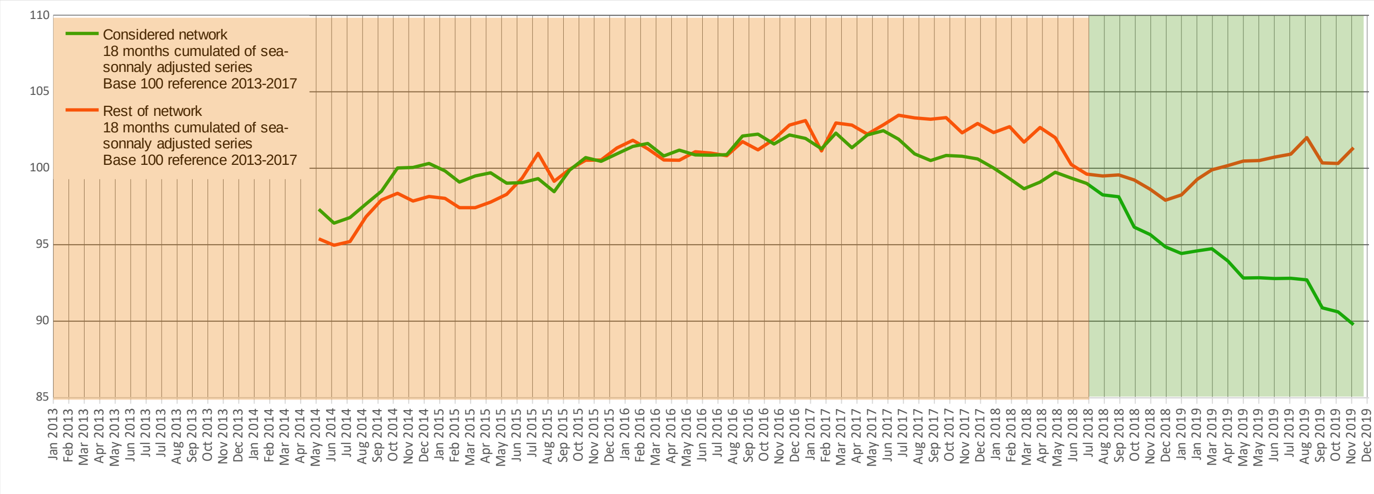


Illustration 17 - Comparative changes on the considered network and on the rest of the network of the sum of deaths over a rolling period of 18 months, in seasonally adjusted data and taking as base 100 the average value of the reference period of 18 months (2nd semester average + whole year average in 2013-2017).

Over the period prior to the measure, the 18-month rolling sums on the two networks follow a similar trend, even though over the period April 2017-June 2018 the two curves diverge and then converge: the 18-month sums remain close to what the reference sums are for either network (value 100).

In the period after the measure, however, the discrepancy is glaring. While the sum of the last 18 months on the rest of the network, after a slight drop until December 2018, is on the rise again, stabilising at a value close to that of the reference period (index around 100), **the considered network begins a downward trend in the number of deaths as of July 2018.**

In order to compare these two trends, an odds ratio approach is proposed as outlined in the method (see part 3.2.6).

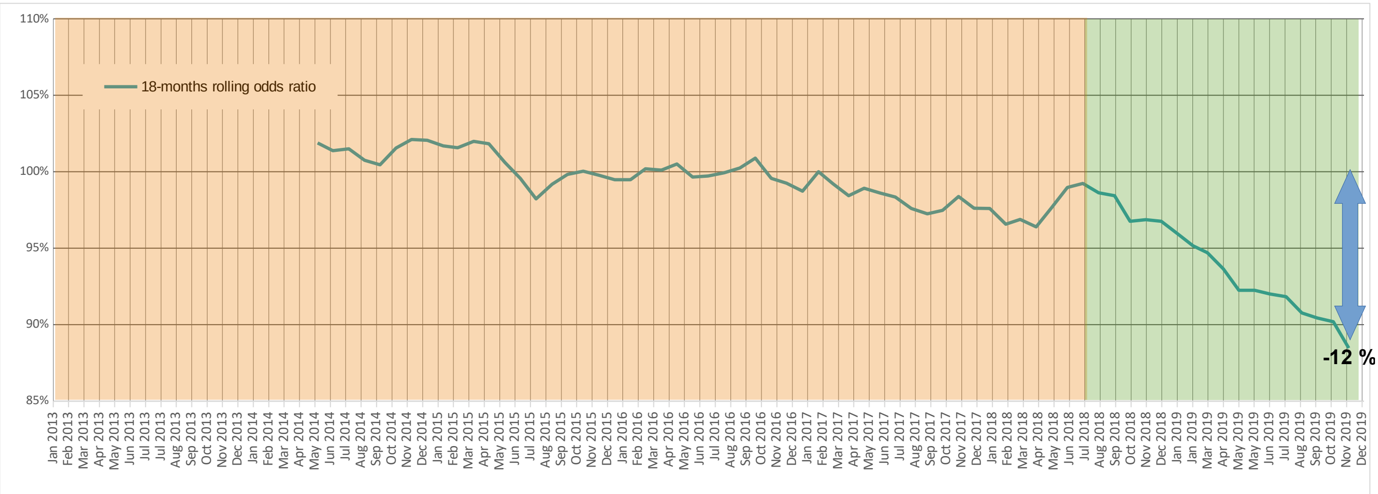


Illustration 18: Changing odds ratio calculated on the rolling 18-month cumulative total between the considered network and the rest of the network

Illustration 18 shows that the odds ratio has been decreasing for every month since July 2018.

This means that, since July 2018, when the measure was implemented, the number of deaths on the considered network has been falling steadily at a rate of -0.6% to -0.7% per month compared with the rest of the network.

After 18 months of application of the measure, the odds ratio shows a decrease of around 12% in road deaths observed on the considered network compared with the rest of the road network in mainland France *(with a maximum error estimate of 3.6%)*. This ratio makes it possible to estimate the impact of the measure on the death rate.

Put another way, **on the considered network,**

- in seasonally adjusted terms, **the gross gain over the 18 months is 331 deaths**[16],
- if one considers, by reference to the rest of the network that constitutes the odds ratio control group, **what would have happened if this considered network had changed in the same way as the rest of the network, then the estimated gain over 18 months would be 389 deaths**[17].

5.1.4 - The trend continues in early 2020

Accident data for early 2020 are still provisional, uncertified, and subject to uncertainty because they have not been verified and have not yet been perfectly stabilised. These data, made available by ONISR, are estimated from the BAACs, preBAACs (BAAC files currently being entered), and accidents reported by rapid feedback from prefectures.

Examination of the raw data on the number of deaths on the considered network shows that from March 2020 accidents, like traffic (see part 1.4), have undergone a sudden change related to the Covid19 pandemic (illustration 19). It is therefore not possible, as of March 2020, to carry out any study whatsoever on the subject of the 80 km/h measure.

Only the months of January and February can therefore be taken into account for the first half of 2020, *with the proviso that the accident data are "estimated".*

Examination of the "estimated" raw data for these two months leads to the following observations:

- In January 2020:
  - on the considered network, the 156 deaths are 6 above the reference average of January 2013-2017, but are significantly higher than the 133 deaths of 2019[18],
  - On the rest of the network, January's 104 deaths put the month at 7 deaths above the average, but at the same level as 2019 (106 deaths).
- In February 2020:
  - on the considered network, the number of 120 deaths is significantly lower than the reference[19],
  - on the rest of the network, on the other hand, the number of 102 deaths is significantly higher than the reference[20].

---

[16]the 18-month total of 2,907 SAD deaths is compared to the reference 3,258.50 SAD deaths - see Table 5.

[17]12% of 3,238.5 reference SAD deaths, with an estimated error of 3.6% establishing the confidence interval [383;395].

[18]The 156 estimated deaths are above the average for the reference period 2013-2017 (150 deaths), but within the confidence interval. On the other hand, they are above the 133 deaths in January 2019.

[19]the 120 estimated deaths (for a February with 29 days) are 24 below average, well below the 95% confidence interval [133.7; 154.9].

[20]the 102 estimated deaths in February are 16 higher than the observed mean, a significant difference (the confidence interval around the observed mean of 86 deaths for the months of February is [78.1;94.5]).

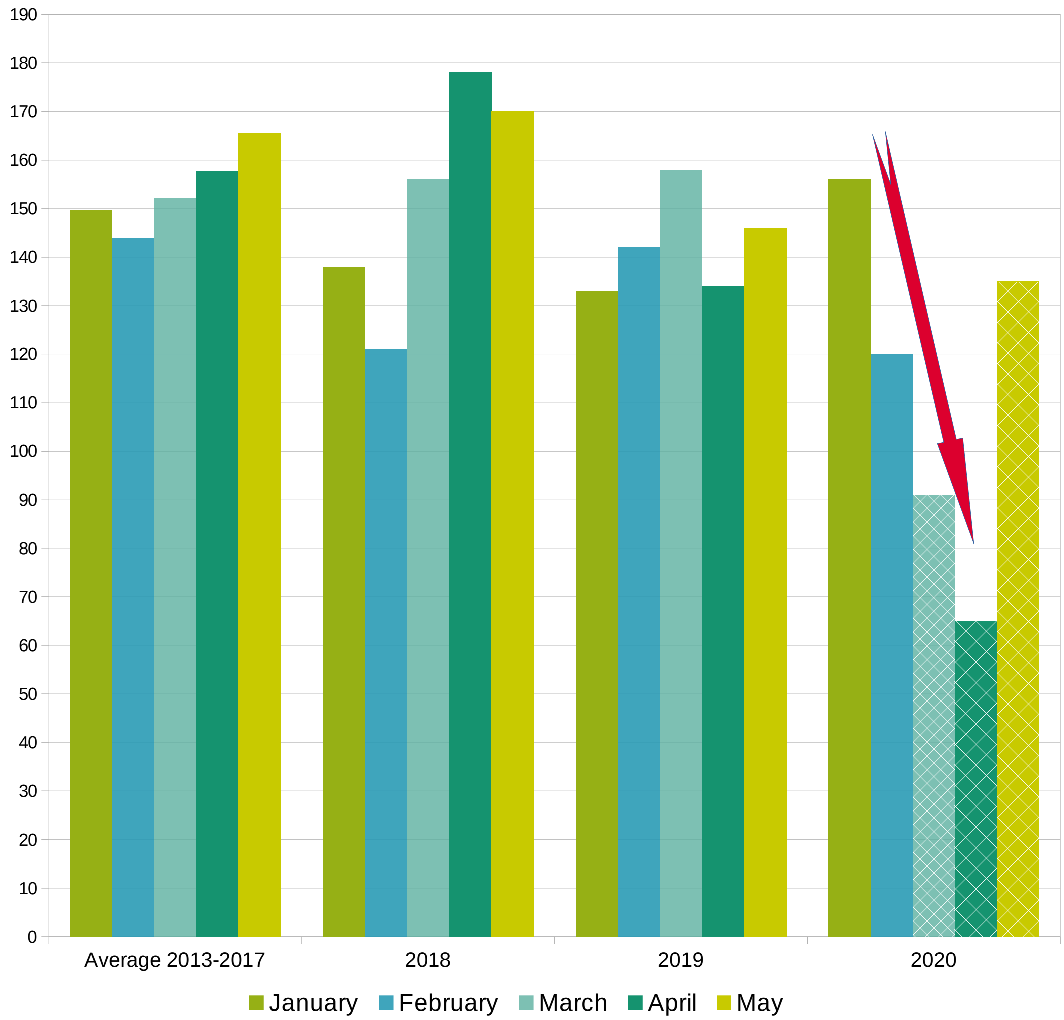


Illustration 19 - Evolution of the number of deaths in early 2020 on the considered network - Source: Official BAAC 2013-2019 and estimated ONISR data for 2020

It has been possible to include the data for January and February in order to obtain, as was done previously with the final data, a 20-month trend for the measure.

Similarly, a further seasonal adjustment of the data was carried out (see appendix 5.4) to give the following reference table:

		2nd half-year 2013-2017	Average year 2013-2017	Average January 2013-2017	Average February 2013-2017	Total reference period 20 months
Considered network	*K*	1087.4	2151.0	183.9	180.8	3603.0
Rest of network	*M*	635.9	1256.6	103.5	99.1	2095.1

Table 6 - Average SA data of the reference number of deaths for a 20-month period, based on SA data for the period 2013-2017

The new odds ratio over 20 months was 87% in February 2020 with an estimated error of 3.5%: the gain for the considered network, all other things being equal, was then 13%.

This approach makes it possible to assert that on the considered network, over the period July 2018-February 2020:

- in seasonally adjusted terms, the gross gain over 20 months is 349 deaths[21],
- if one considers, by reference to the rest of the network that constitutes the odds ratio control group, what would have happened if this considered network had changed in the same way as the rest of the network, then the estimated gain over 20 months would be 468 deaths[22].

5.2 - Number of injury accidents stabilized at the reference level

For the following parts, the data are processed as raw figures and are therefore analysed by year.

It should first be noted that **the considered network accounts for about a quarter of the accidents resulting in injuries, while almost two-thirds of deaths are attributable to it.**

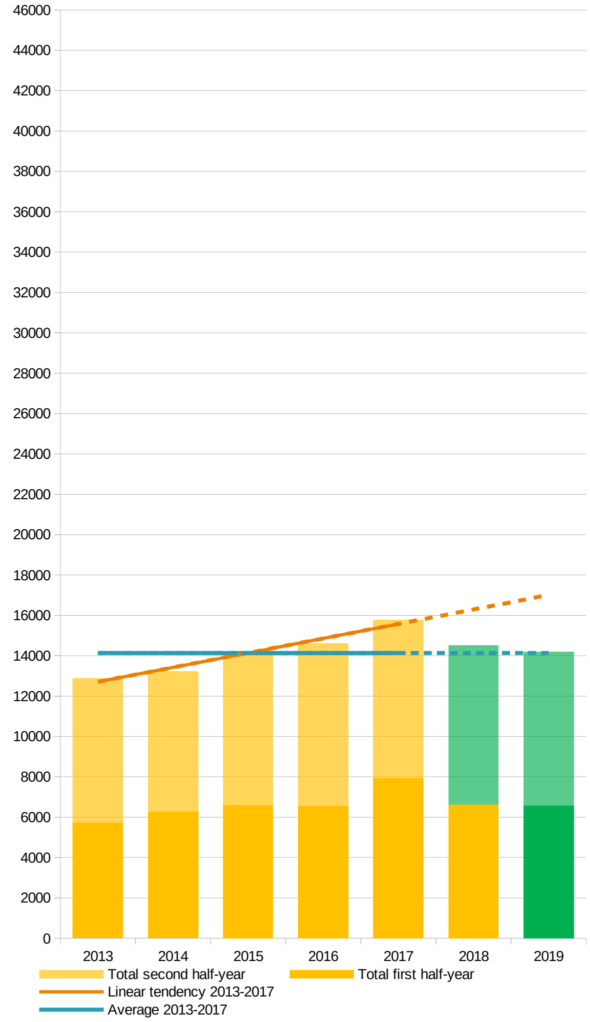


Illustration 20 - Comparison of the number of accidents on the considered network, by year (Source: Official BAAC)

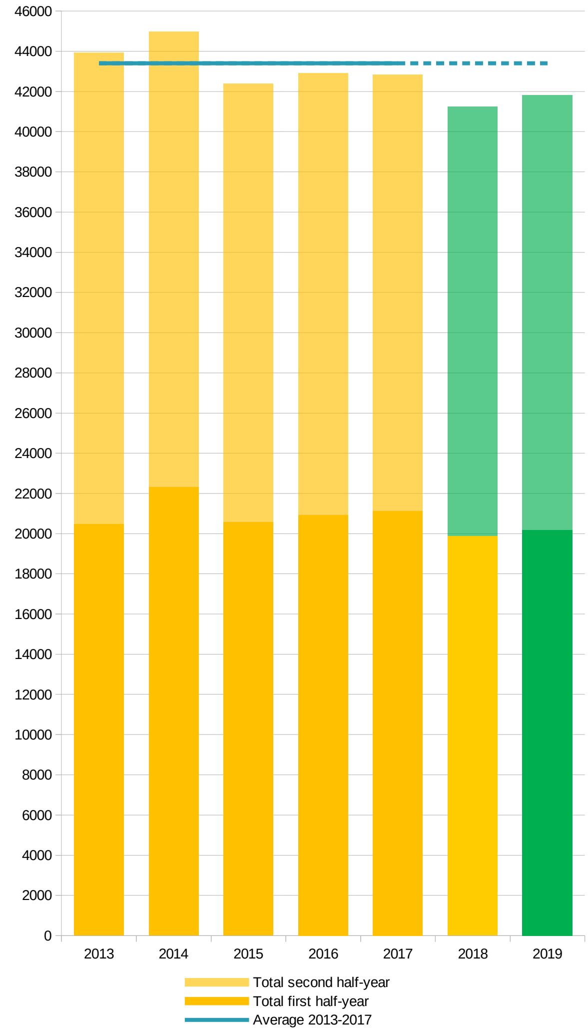


Illustration 21 - Comparison of the number of accidents on the rest of the network, by year (Sources: Official BAAC)

[21] the total of 20 months of the measure, 3,254 SAD deaths, is compared to the reference 3,603 SAD deaths

[22] 13% of 3,603 reference SAD deaths, with an estimated error of 3.5%.

In 2019, the number of injury accidents on the considered network at the reference level stabilized, and decreased on the rest of the network.

On the considered network, the period 2013-2017 reflected a regular increase, while the 2018 and 2019 even more so mark a decrease compared to this trend. However, compared to the 2013-2017 reference average, the number of injury accidents in 2018 and 2019 was stable (illustration 20).

The rest of the network did not experience a significant increase over the period 2013-2017 (illustration 21). A decrease in the number of accidents is observed in 2018 and 2019. This decrease is significant.

5.3 - A drop in the death rate

The previous observation concerning the number of accidents, in relation to the number of deaths, suggests a very different change in severity between that on the considered network and that on the rest of the network. The figures are presented in appendix A 4.4.

The overall number of victims per 100 accidents is similar, with 150 victims on the considered network for 125 on the rest of the network.

On the considered network, this number fell slightly in 2019 (150.5 compared with 152.7 over the period 2013-2017).

In contrast, the death rate is very different between the two networks. In fact, for every 100 accidents, there were no fewer than 15 deaths on the considered network and only 3 deaths on the rest of the network during the reference period. **In the event of an accident causing personal injury, the probability of being killed is five times higher on the considered network than on the rest of the network.**

On the considered network, a 10% decrease in the death rate was observed in 2019 (13.7 in 2019 compared to 15.2 over the period 2013-2017). **This phenomenon cannot be seen on the rest of the network,** where, on the contrary, a 1% increase in the death rate is noted in 2019.

5.4 - Moderate effects in certain driving situations

The measure could lead to a change in the behaviour of road users, and bring out a particular accident rate. Overtaking and rear-end collisions were given particular focus on the considered network. The figures are given in appendix A 4.5 and A 4.6.

5.4.1 - Overtaking manoeuvres are part of the general trend

This type of manoeuvre on the considered network is related to around 1,000 injury accidents per year, and causes the death of around 130 people.

The data for this type of accident change in a similar way to what is observed for all injury accidents:

- a halt to the upward trend in the number of accidents but a slightly higher accident rate than the reference average,
- a sharp drop in 2018 and 2019 in the number of deaths related to overtaking manoeuvres.

There does not therefore appear to be any change caused by the measure to the accident rate related to overtaking other than the change observed in the accident rate in general.

5.4.2 - More deadly rear-end and chain collisions, except with HGVs

The overall review of rear-end or chain collision accidents shows that the number of accidents stabilized in 2018 and 2019, below the 2017 figure but above the 2013-2017 reference average.

On the other hand, **the number of deaths in rear-end collisions** shows a more disparate trend, with a non-significant decrease in 2018 and **a very significant increase in 2019** (illustration 22), where the 128 deaths are 20% higher than the 2013-2017 reference.

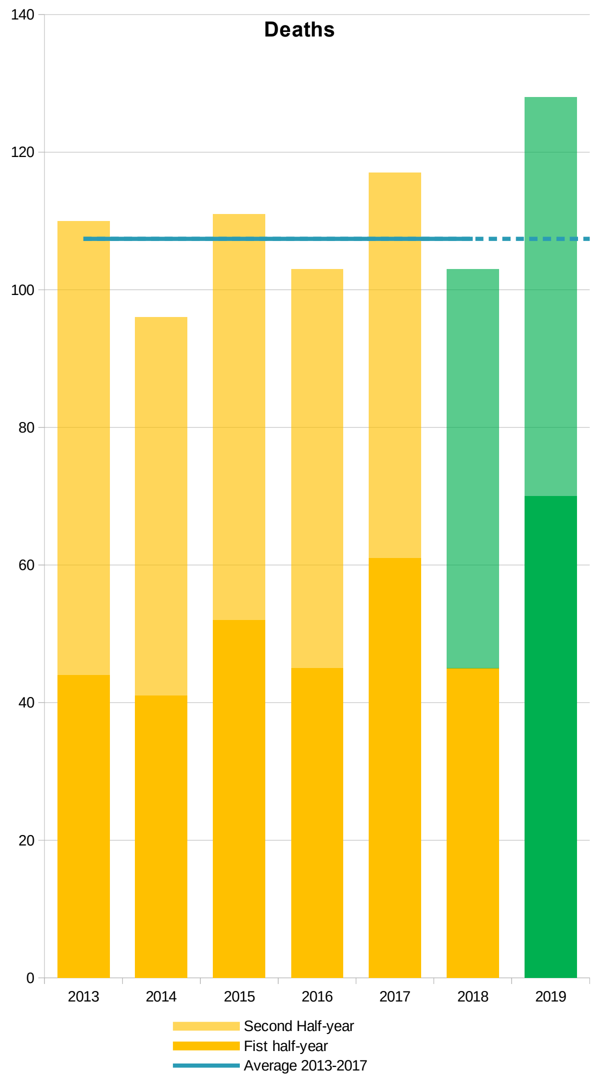


*Illustration 22 - Number of people killed in **rear-end collisions**, by year- Source: Official BAAC*

This part examines rear-end collisions involving heavy goods vehicles.

Firstly, **it appears that HGVs are involved in only 11% of rear-end collisions.** This figure is stable over the entire study period.

The number of this type of accident stabilized in 2018 and 2019, below the 2017 value but above the 2013-2017 reference average.

In contrast, **the number of deaths in rear-end collisions involving at least one HGV fell sharply in 2018 and 2019** (Illustration 23), a substantial decrease[23].

The details of the type of rear impact or chain impact involving an HGV were examined according to the point of impact, whether it was the HGV that struck another vehicle from behind or, on the contrary, whether it was the HGV that was struck, and whether the proportions between these two types of collision changed when the measure was introduced.

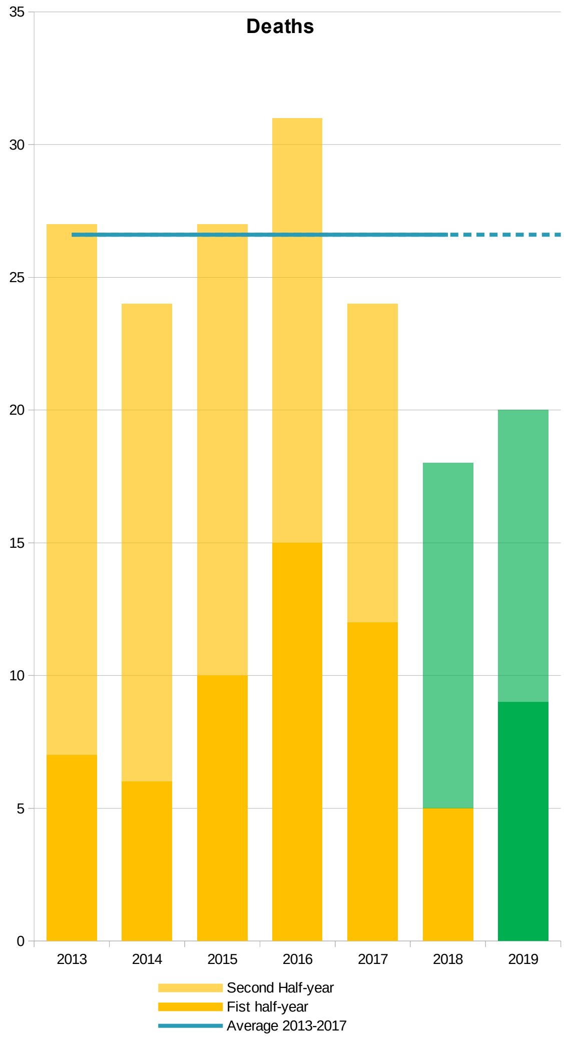


*Illustration 23 - Number of **people killed in rear-end collisions involving an HGV**, by year- Source: Official BAAC*

[23]With 18 deaths per year in 2018 and 20 in 2019 (9 and 7 deaths respectively less than the reference average), these accidents present a very favourable outcome, below the lower bound of the 95% confidence level of expectation ([22,6;32]).

The result, given in Table 7, shows that there has been no change in the trend: in 52% of rear-end and chain collision accidents involving an HGV, it is the HGV that strikes, while in 41% it is the HGV that is struck. The measure has not significantly affected this distribution.

	Before measure 2013-2017	After measure July 2018-December 2019
Sriking HGV: accidents in which the HGVs involved collide at the front.	541 *52.0%*	169 *50.6%*
Struck HGV: accident in which the HGV involved are struck at the rear.	428 *41.1%*	136 *40.7%*
Mixed accidents , with striking HGV and struck HGV	72 *6.9%*	29 *8.7%*

Table 7 - Comparison of the number of accidents on the considered network, of the rear-end or chain collision type involving an HGV, between the "before" period from 2013 to 2017 and the "after" period from July 2018 to December 2019 (Source: Official BAAC)

This just confirms the conclusions of the approach of part 4.3.3 in which it has been shown that HGVs do not drive any closer to the vehicle in front of them than before.

6 - Travel time

An assessment of the effect of the measure on travel times was carried out using two complementary methods: with the Google Maps application and with historical GPS tracks.

The Google Maps data make it possible to cover wide range of itineraries affected by the measure and spread over the whole of France. However, they represent the travel time estimated by the Google algorithm at time “t”. For this reason, they can be collected only in real time. Thus the “before” period is limited to June 2018.

For this reason, further work has been carried out on the use of historical Floating Car Data (FCD) vehicle tracks. Although this work covers a more restricted area, it does however make it possible to extend the analysis periods and so smooth out one-off (work, accidents, weather) or seasonal factors (tourist traffic) likely to cause significant variations in travel times for the various routes selected.

The characterization of the time lost per user is expressed in seconds per kilometre.

6.1 - Average travel time increase of 1 second per kilometre according to Google Maps

To do this, Cerema took a reading of journey times from the Google Maps application algorithm “before” and “after” the measure to reduce the speed limit to 80 km/h was implemented. Using the Google Maps application makes it possible to automatically start collecting data at the same time on all selected routes.

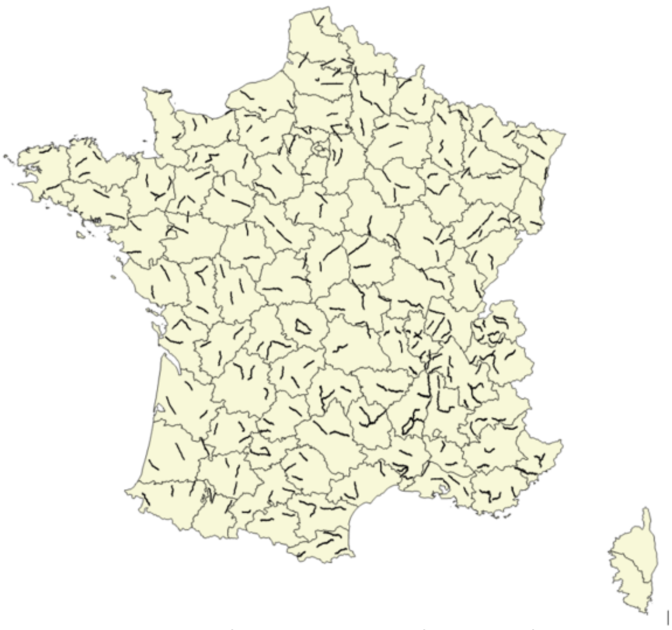


Illustration 24: Representation of 297 routes analysed for travel times before and after implementation of the 80 km/h measure in mainland France (Source: Cerema)

The surveys covered 297 routes of between 25 and 30 kilometres in length, spread over all the departments of mainland France. They total a linear length of 7,551 kilometres.

These routes favour commuting (i.e. daily trips between home and work). According to an INSEE survey, three quarters of employees travel by car less than 26 kilometres to reach their place of work (Coudène and Levy, 2016).

They include a minimum of 70% of two-way roads outside urban areas where speeds are restricted to 80 km/h. Potential exclusion criteria were taken into account, such as weather conditions or road works. The routes selected in mainland France are shown in illustration 24.

Travel time readings using Google Maps were made:

- in the week before the measure, or June 25 to 30, 2018,
- one year after setting up the measure, i.e. from June 24 to 30, 2019, excluding the summer period.

The times of the readings are as follows:

- at 8 am for morning commutes,
- at 5 pm for evening commutes,
- at 10 am and 3 pm for trips other than commuting,
- on Saturdays at 3 pm.

The first three readings illustrate an average daily travel time during the week.

On average, over all 298 routes, **the results obtained with Google Maps show an increase in travel time from 1 July 2018 of roughly one second per kilometre on a commuting trip** (average daily time lost on weekdays).

This order of magnitude reflects disparities according to the routes. The table shows the distribution of the number of routes according to the gains or increases in travel time before and after implementation of the measure on the routes in mainland France.

	Gain in travel time (second/km)		Increase in travel time (second/km)	
	June 2018/ June 2019	*(% of total routes)*	*June 2018/ June 2019*	*(% of total routes)*
Less than 1 s/km	32	*11 %*	72	*24 %*
Between 1 and 2 s/km	9	*3 %*	83	***28 %***
Between 2 and 3 s/km	6	*2 %*	40	*14 %*
Greater than 3 s/km	9	*2%*	46	*15%*
	56	***19 %***	**241**	***81%***

Table 8 Breakdown of the number of routes according to increases in average daily travel time, on weekdays, from June 2018 to June 2019 for all vehicles (Source: Google Maps)

Between June 2018 and June 2019, it turns out that:

- 81% of the routes show an increase in average daily travel time, of which 24% are of less than 1 second, and 28% between 1 and 2 seconds per kilometre.
- For 19% of the routes, a gain in travel time was measured. This is mainly of less than 1 second.

6.2 - One second per kilometre confirmed by GPS tracking on daily trips

The journey time records by GPS historical tracking were made with the TomTom Move Traffic stats tool.

The work covered a panel of 154 routes from the selection made in the previous phase (see appendix 7). They represent a total length of 3,983 km of roads, i.e. an average of 25.8 km per route. They are located in at least 83 different departments[24]. An evaluation of the maximum permissible speeds on a sample of 19 routes confirmed that the average route comprises 80% of the length affected by the speed reduction measure.

The travel times obtained are thus representative of a panel of daily routes.

The aim was to compare the journey times over a period of 3 consecutive months in 2017 and 2019. The time of the study was determined in detail:

- excluding the period of road traffic disruptions related to the g*ilets* j*aunes* movement,
- excluding as far as possible the atypical months in terms of traffic and weather (winter night period and rainy months),
- comparing the same months between 2017 and 2019 to avoid the effects of seasonal variations on travel times,
- choosing a period to ensure that the date were available (processing time between the collection of the data by Tom-Tom and its availability in the tool),
- taking into account that traffic was relatively stable between 2018 (August to October) and 2019 (August to October) according to the road traffic report of transport accounts.

The periods of study selected are therefore:

- from August 1 to October 31, 2017, for the period “before” the measure,
- from August 1 to October 31, 2019, for the period “after” the measure.

The 24 hours of the day are divided into time slots, making it possible to distinguish between different times of day and different traffic conditions:

- 7:00 am to 9:00 am for the morning rush hour,
- 9:00 am to 5:00 pm for off-peak time,
- 5:00 pm to 7:00 pm for the evening rush hour
- and 7:00 pm to 7:00 am for the “night” hours.

For weekends, a time slot from 10 am to 7 pm was defined per day (Saturday and Sunday).

For the whole data collection, journey times of 1,458,000 vehicles were collected (see appendix7 for details). Only vehicles that complete the entire route have their GPS tracks taken into account for a better approach to overall travel times. On all routes, the average daily traffic per kilometre travelled is 3,782 vehicle per day (1 direction of travel).

The cumulative travel volumes for all routes, as measured by the vehicle-km indicator, are assumed to be the same for the two years 2017 and 2019 and **amount to 5.50 billion vehicle kilometres.**

[24]A route, even if it passes through more than one department, is referenced only in one department.

The average daily travel time was reconstructed on the basis of the GPS tracking collection. This travel time is obtained by summing the travel times by hourly periods, and assigned the coefficient of the GPS sample of the period in relation to the sum of the daily GPS samples.

Between 2017 and 2019, the average increase in journey times revealed by the historical GPS tracks, weighted by the volume of traffic on the routes studied, amounts to 0.98 s/km travelled. This result confirms the estimate obtained with the Google Maps application.

Of the 154 routes studied:

- 88% of the routes saw an increase in travel time, mostly less than 3 s/km travelled.
- 12% of the routes saw a reduction in travel time, the vast majority of which is less than 1 s/km travelled.

An analysis of the distribution of 2017-2019 increased journey times as a function of traffic did not show a significant correlation between traffic loads and increased journey times. This analysis also shows a decrease in journey times concentrated on routes with low initial average speeds.

On average, travel times increase significantly more at weekends than on working days (table 9). On working days, the evening rush hour has the highest increase in travel time, and the night hours (7pm - 7am), the lowest.

	Average increased travel time in s/km travelled	*For a regular 30km trip, in seconds*	*For an 80km trip in seconds*
Morning Rush Hour (Working day)	0.86	*25.8*	*68.8*
Off-peak time (Working day)	0.84	*25.2*	*67.2*
Evening Rush Hour (Working day)	1.11	*33.3*	*88.8*
(Night) time 7pm-7am (Working day)	0,69	*20,7*	*55,2*
Saturday 10am-7pm	1,41	*42,3*	*112.8 (1min 52s)*
Sunday 10am-7pm	**1.42**	***42.6***	***113.6 (1 min 53s)***

Table 9 distribution of average increased travel time from historical GPS tracks (source: Cerema calculation, 2020)

For “regular” journeys of around 30km, the average increase in journey time is around 30 seconds during the week and 40 seconds at the weekend.

For journeys of around 80km, which correspond to crossing a department for example, the average increase in journey time is around one minute during the week and less than 2 minutes at the weekend.

7 - Environmental impacts

7.1 - A slight decrease in noise pollution not perceptible to the human ear

The acoustic impact of the 80 km/h measure was evaluated using two complementary methods:

- via calculation from acoustic simulation models.

This work was carried out on 4 road sections affected by the measure (N31; N79; N94 and D612). The simulation of noise emissions from the vehicle fleet and the overall assessment of the areas exposed to noise were carried out using Mithra-Sig V5 prediction software; the emission and propagation method is based on NMPB08 (*Nouvelle Méthode de Prévision du Bruit 2008* - New Noise Prediction Method 2008),

- via in situ noise measurements.

The principle involves comparing, on a section affected by the speed reduction measure, the results of acoustic measurements carried out close to the lanes before and after implementation of the 10 km/h reduction in the speed limit. This measurement was made using a sound level meter located on the facade of a house bordering the infrastructure, in accordance with standard NFS 31-085 "Characterization and measurement of noise due to road traffic". This study was conducted on the N85 in Alpes-de-Haute-Provence.

Several indicators were used to quantify the impact of the VMA80 measure using these two methods:

- an indicator intrinsically characterising the source of road noise (Lw/m). It represents the linear sound power level emitted by the stream of vehicles on the portion of lane being tested. This indicator is generated only by calculation/modelling.
- two energy indicators to qualify noise levels: LAeq, Lden (indicators relating respectively to French and European regulations).
  - LAeq, A-weighted equivalent continuous sound level, is used to characterize a sound level at a given point, during a given period. French regulations set 2 regulatory periods: 6 am-10 pm (day-time period) and 10 pm-6 am (night-time period). This indicator is used in France to assess the acoustic impact of transport development projects and during in situ noise measurements,
  - Lden, the European indicator of global noise level in dB(A) over 24 hours; this indicator, used in the field of strategic noise maps, is calculated on the basis of equivalent noise levels averaged over three periods: day (6 am-6 pm), evening (6 pm-10 pm), and night (10 pm-6 am).

Unlike Lw/m, these indicators (Laeq and Lden) characterize the sound level at a given point. These indicators are used both during in situ measurements (façade noise measurement; Laeq) and during modelling (in the present case, MithraSIG is used).

7.1.1 - A modelled decrease of 0.8 B(A) for a speed reduction from 90 to 80 km/h

To model the acoustic impacts of speed reduction, Cerema selected 4 sections along the N31, N79, N94 and D612, representing distinct characteristics in terms of road flows, percentages of heavy goods vehicles and lane function (table 10). It was not possible to model the whole French road network effected by lowering the speed limit to 80 km/h.

Lane location of the section	**N31** between Beauvais and Compiègne	**N79** between Paray-le-Monial and Mâcon	**N94** between Gap and Embrun	**D612** entre Saint-Chinian et Béziers
Annual average daily traffic(TMJA) (veh/j) on the road section being studied	20,580	13,308	14,596	11,132
% HGVs on the road section being studied	12,0	25,5	9,2	10,8
function	interregional	interregional	regional	local

Table 10 characteristics of the sections selected for noise emission modelling

Noise emissions (expressed in sound power level; Lw/m) were calculated on the 4 road sections, using the Mithra -SIG V5 tool. They take into account the following parameters: AADT and percentage of HGVs, broken down over 24 hours into to four pre-defined regulatory acoustic periods (6 am-6 pm / 6 pm - 10 pm / 6 am -10 pm and 10 pm - 6 am). In this way, the approach makes it possible to obtain average hourly flows for light vehicles and heavy goods vehicles. This break-down is in line with the recommendations on the "Predictive calculation of road noise - daily traffic profiles on inter-urban roads and motorways" (Setra report; 2007) and the speed limit (90 km/h (before) versus 80 km/h (after).

For the 4 sections studied, the calculated noise emissions systematically decrease in the move down from 90 km/h to 80 km/h. The decreases are very small, all less than 0.8 dB(A), and are almost imperceptible to the human ear.

The results are detailed in appendix 8. This observation is valid over all the regulatory periods in question (day and night), whether based on French or European regulatory periods.

The roads with the least traffic and the least HGV loads are those where the measure has a higher effect in terms of noise emission (N94; D612); the ranges of variation, however, remain very small (between - 0.4 and - 0.7 dB(A)).

The section of the N79 (part of the RCEA), which has a heavy HGV load, is where the measure has had the least effect, i.e. < - 0,4 dB(A), whatever the time of day.

This finding is in line with the observation of ADEME (2014), which stressed that the large proportion of heavy goods vehicles could "absorb" the benefit of the speed reduction on light vehicles. Moreover, in this situation (with a high percentage of HGVs), the decrease in noise emissions is considered less noticeable at night (the situation observed on the N79), as the proportion of HGVs is higher than during the day.

The use of noise maps and isophonic curves provides a spatialized view of the effect of the measure. It was carried out on 2 sections: along the N94 at Montgardin (illustration 25) and along the RD612 at Béziers (illustration 26).

It is clear that the soundscape for local residents remains unchanged.

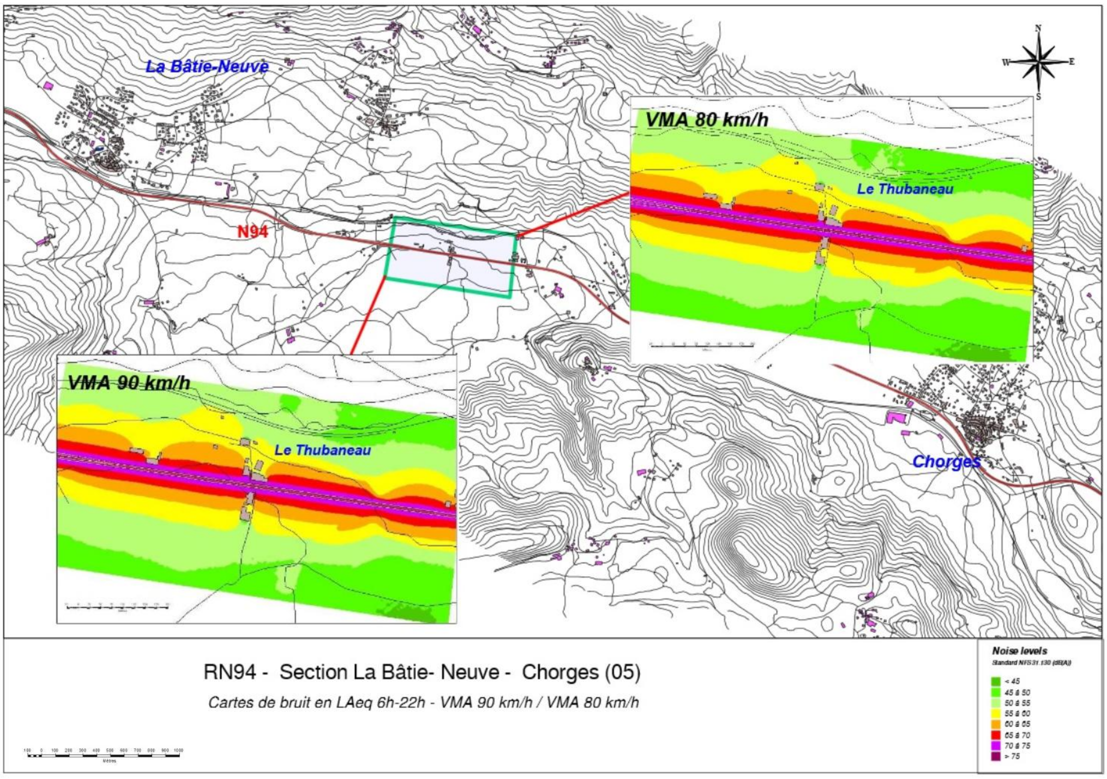


Illustration 25: Comparison of the effect of the VMA80 measure along the N94 at Montgardin.
Noise map (type A map; daytime period 6 am - 10 pm) - isophonic curves showing areas with the same sound level

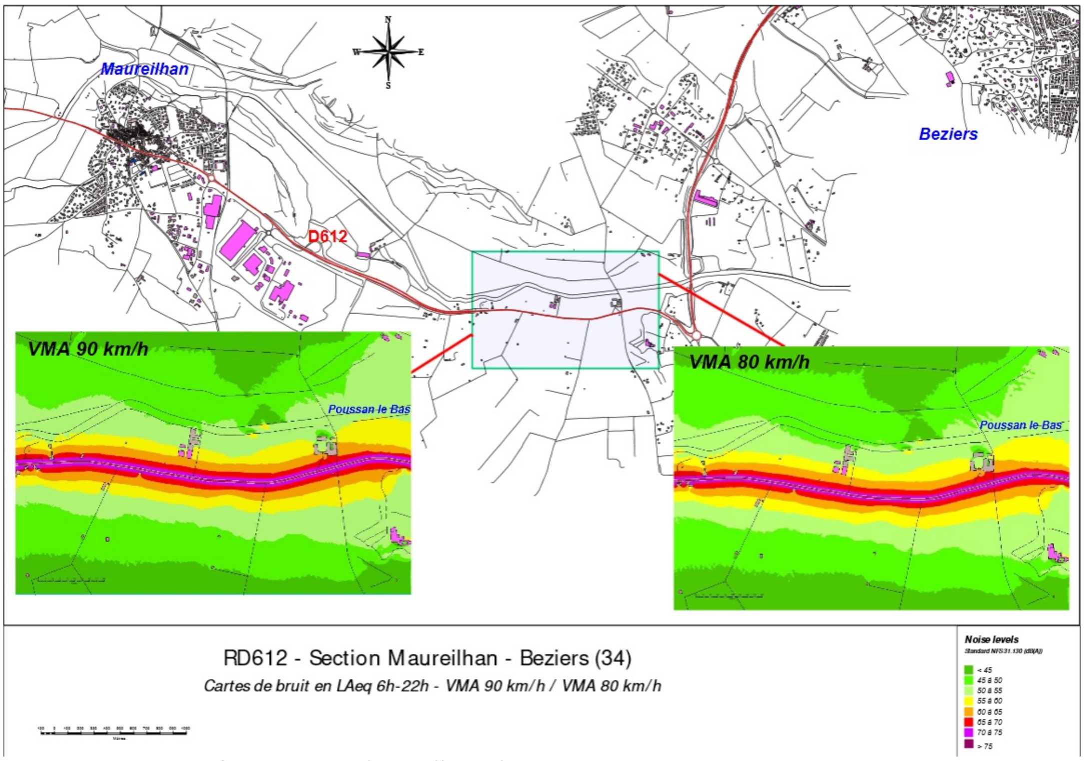


Illustration 26: Comparison of the effect of the VMA80 measure along the RD612 at Béziers.
Noise map (type A map; daytime period 6 am - 10 pm) - isophonic curves showing areas with the same sound level.

7.1.2 - No significant impact on in situ noise measurements

A site meeting the necessary requirements (road section affected by the VMA80 measure; acoustic measurements carried out prior to the measure) was tested in 2019. It is located along the N85 between Château-Arnoux-Saint-Auban and Digne-les-Bains in Alpes-de-Haute-Provence.

This site had already undergone a measurement campaign, including acoustic measurements, in 2013, as part of another project. In 2019, the sound level meter was installed at exactly the same location as in 2013.

On this route, the speed readings recorded in 2013 and 2019 show a very slight change in speeds (of the order of -2 km/h).

A comparison of in situ acoustic measurements at a point along the N85 shows that the noise levels recorded in 2013 and 2019 (levels reset to 2013 traffic levels) **are practically identical:** the difference in sound level between the 2 dates is less than 0.5 dB (A).

This result is observed regardless of the period being evaluated (day and night) and regardless of weather conditions. The very small variations observed here fall within the uncertainty range of the data acquisition/mobilisation chain in the field of environmental acoustics; the uncertainty items being linked both to the physical phenomena present (instrumentation) and to the experimental method used (Ecotière, 2014).

In the vicinity of the house question, it can be concluded that the noise differences are below measurement uncertainty. The VMA80 measure has no measurable impact on sound levels.

This in situ noise measurement study is consistent with previous results, showing that while a reduction in the speed limit leads to a small variation in the operating speeds, it has no measurable impact on in situ noise measurements.

Although the number of situations examined in this study is modest, the results obtained are therefore consistent with those in the literature.

7.2 - Slightly positive effect on air quality

The aim is to assess, as quantitatively as possible, the effects of lowering the speed limit on air quality, mainly on the emission levels of air pollutants with an impact on health (local pollutants) and on the emission levels of greenhouse gases (GHGs) with an impact on climate change. The pollutants studied are:

- carbon dioxide (CO2), for greenhouse gases,
- nitrogen oxides (Nox), particulate matter (PM10 and PM2.5) and benzene, for local pollutants.

The analysis consists of estimating the emissions of air pollutants before and after implementing the lower speed limit. The aim is to have, on a sample of routes subject to the lowered speed limit and for which traffic and speed data are available, an estimate of the impact of lowering the speed limit based on average speeds before and after the measure was implemented, using GPS track records of vehicles.

The sample selected comprises 6 routes spread over mainland France with different characteristics in terms of speed, percentage of HGVs and route gradient (table 11. It is these 3 factors that can explain relative differences in estimated emissions between two readings before and after implementation of the measure (see 2.4, reviewing the literature on the subject). The percentage of heavy goods vehicles varies from 4 to 43% depending on the routes examined.

Speeds vary for situations before and after the measure was implemented. All the selected routes have average speeds in excess of 70km/h. In relation to this threshold, of the 6 routes, 2 routes have high average speeds (between 80 and 90 km/h) and 4 routes have moderate average speeds (between 70 and 80 km/h).

The decreases in speed are significant for the 2 routes on which high average speeds are observed. They are less so on the 4 routes that have moderate average speeds.

French department	Length in km	Average daily traffic in number of vehicles	Proportion of HGVs	Speed before the measure (km/h)	Speed after the measure (km/h)
Pas-de-Calais	35,8	6,128	32%	71,0	70,0
Aube	28,6	10,235	8%	74,8	72,1
Hautes-Pyréenées	28,5	2,200	14%	76,3	75,1
Loire-Atlantique	26,9	11,700	4%	83,5	77,5
Allier	26,5	15,760	43%	90,5	87,4
Var	29,5	3,280	13%	71,0	70,4

Table 11: Main characteristics of the routes studied for assessing the impact of the measure on air quality

To estimate the emissions of atmospheric pollutants, the COPCETE v4 software of the Ministry for Ecological and Inclusive Transition's "Air" Scientific and Technical Network was used. This software[25] is based on the COPERT 4 (*Computer Programme to calculate Emissions from Road Transport*) methodology for calculating pollutant emissions, a methodology resulting from the work carried out since the 1990s by various European organisations and research laboratories.

The criteria for estimating emissions take into account:

- of the annual average daily traffic (AADT) for light and heavy vehicles and the associated speeds;
- of the topography, particularly the gradient, which may be low, medium or high at the level of the project;
- of land use.

The results on the 6 routes show an overall decrease in the main pollutants (illustration 27).

This illustration shows the reduction in pollutant emissions following implementation of the measure, for each route studied, for the main pollutants of road origin (NOx, PM10, benzene) as well as for CO2 (GHG) and as a function of the speed (high or moderate) and the proportion of heavy goods vehicles.

[25]Version 4 of COPCETE (October 2016) includes modifications to version v9.0 of the COPERT 4 software, and takes into account the modification to the structure and update of the French fleet 1990-2030 by IFSTTAR (IFSTTAR fleet, March 2013).

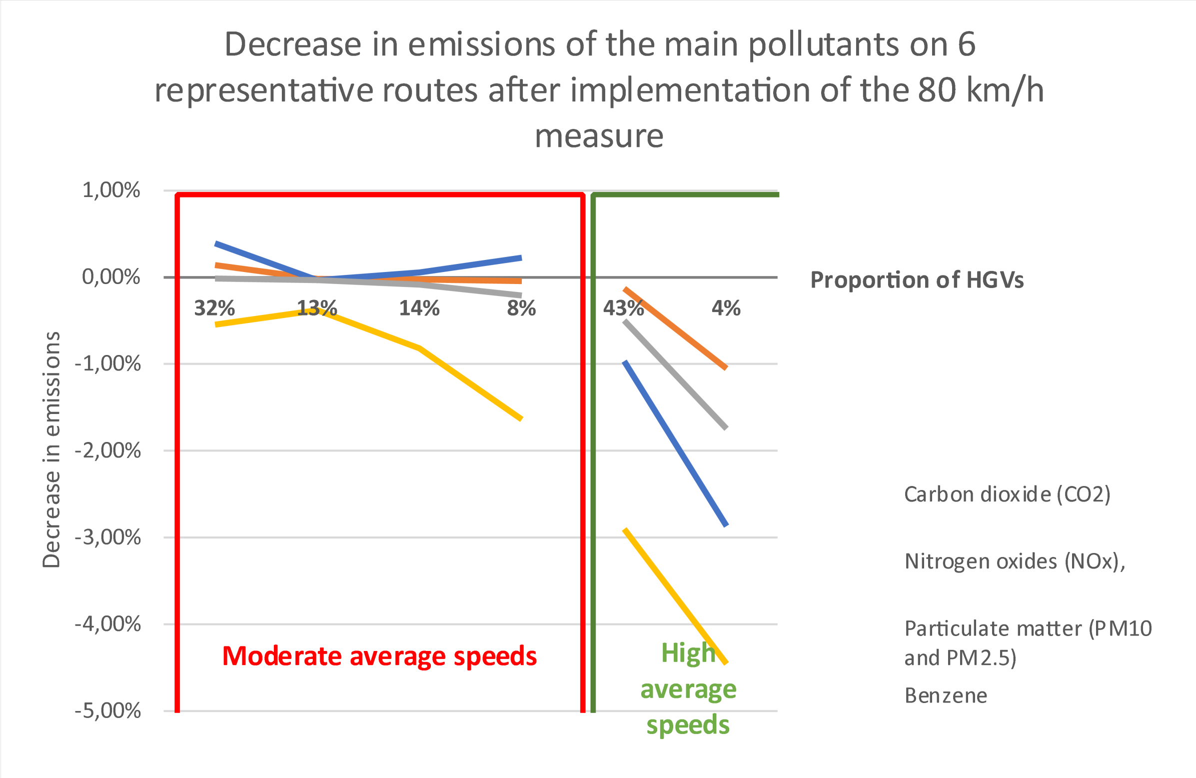


Illustration 27: Decrease in emissions of the main pollutants on 6 representative routes after implementation of the 80 km/h measure (source: Calculation Cerema, 2020)

In detail, for routes with high traffic speeds (80-90 km/h) and a low proportion of heavy goods vehicles, the estimates made correspond to known trends, i.e. that the speed reduction measure brings a significant gain in pollutant emissions. This result makes sense for these speeds as the speed of HGVs was already limited to 80km/h on roads limited to 90km/h. The largest decreases were in nitrogen oxides and benzene emissions (-3% and -4.5% respectively for the route with the largest decreases). PM10 particulate matter emissions are more limited as this pollutant does not come only from exhaust emissions but also from emissions due to tyre friction on the road.

On the other hand, for routes on which the speed is close to 70 km/h, the results vary according to the context (effective speed reduction and proportion of HGVs). For one of these, emission gains for LVs offset the additional NOx emissions from HGVs (13% of HGVs on the route). For the other three, the emission gain gains for LVs does not compensate for the additional NOx emissions from HGVs (the proportion of HGVs varying between 8 and 32%).

In summary, the results tend to show an overall decrease in the main pollutants. However, this decrease is very small and at this stage cannot be considered as significant.

8 - Acceptability / Acceptance of the measure

The results presented below relate to the three waves of the survey:

- "before" implementation of the measure: wave 1 (April 2018),
- "after" implementation of the measure: wave 2 (March 2019) and wave 3 (October 2019).

They have all been statistically tested to verify the significance of the statements made.

A fourth wave of surveys was conducted from 12 to 17 June 2020. It could not be analysed in depth. Only the overall result of subscribing to the measure can be presented in this section.

8.1 - A drop in those most opposed to the measure

After implementation of the measure, a positive change in how it was accepted was noted (illustration 28). The proportion of respondents in favour of the measure continues to grow. It increased from 30% in April 2018, to 40% in March 2019, to 42% in October 2019 and to 48% in June 2020.

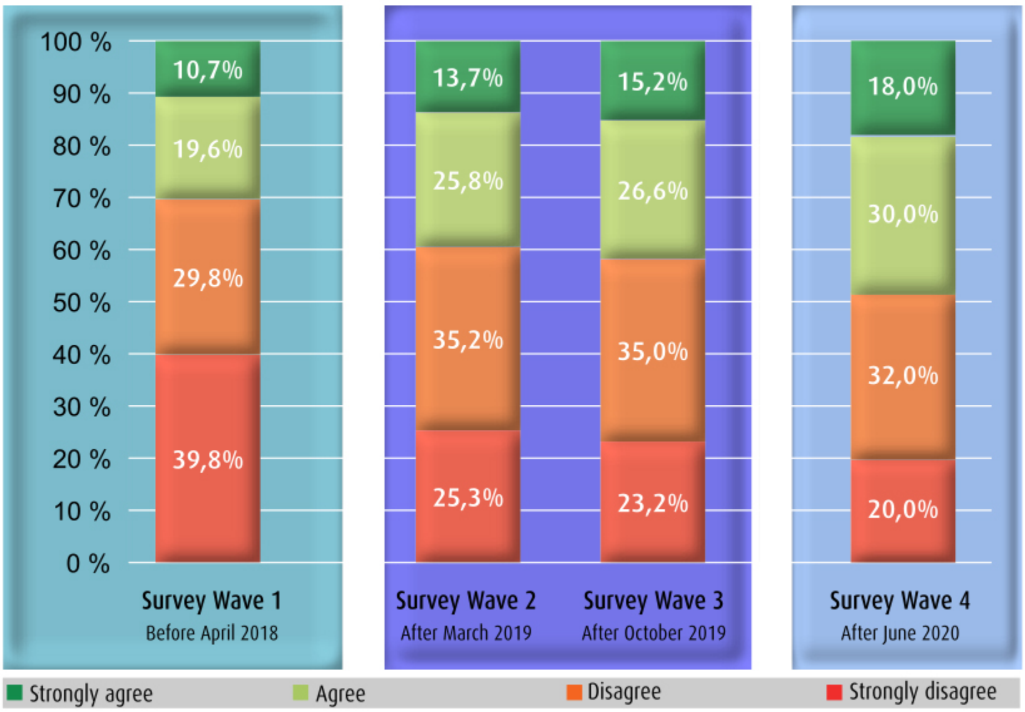


Illustration28: Percentages of respondents on the extent to which they subscribe to the measure, according to the survey waves: wave 1 (April 2018), wave 2 (March 2019), wave 3 (October 2019), wave 4 (June 2020)

For each wave of the survey, **female drivers are more favourable than male drivers** (illustration 29). In June 2020, 53% of female drivers are in favour of the measure compared to 44% of men.

Regardless of gender (male/female), the rate of support for the measure increases. Among male drivers, the proportion of respondents unfavourable to the measure thus decreases from 72% in April 2018 to 65% in March 2019, 64% in October 2019 and finally 56% in June 2020.

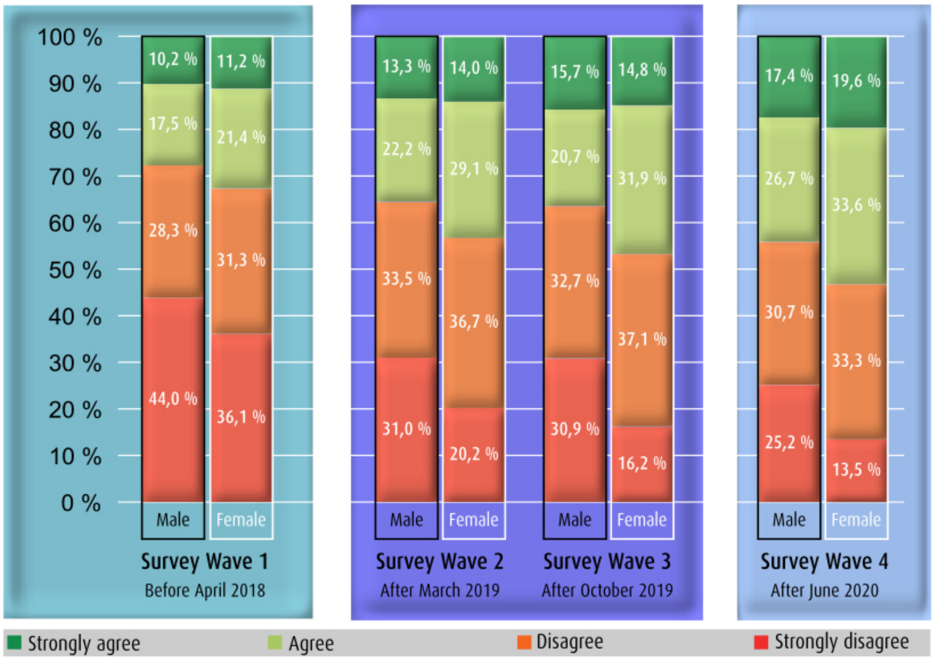


Illustration 29: Percentages of respondents on their level of adherence to the measure, by gender and survey waves: wave 1 (April 2018), wave 2 (March 2019), wave 3 (October 2019), wave 4 (June 2020)

The positive change particularly concerns those most opposed to the measure. The representation of those who "strongly disagree" with the measure decreased from 40% in April 2018 to 25% in March 2019, to 23% in October 2019 and to 20% in June 2020. The reduction in the number of respondents who "disagree" with the measure between wave 1 and wave 2 (Chi2=211 p=1.08 e-45) and wave 3 is significant (Chi2=292 p=3.87 e-63).

This positive change in those most opposed to the measure is particularly pronounced among respondents living in rural areas and in towns with fewer than 20,000 inhabitants.

For respondents living in rural areas (illustration 30), the proportion of people who strongly disagree with the measure fell from 50% in wave 1 to 34% in wave 2, to 29% in wave 3 and to 25% in wave 4 (wave 1/wave 2, Chi 2=57.01; p=2.55 e-12; wave 1/wave 3 Chi 2=40.03; p=2.50 e-10).

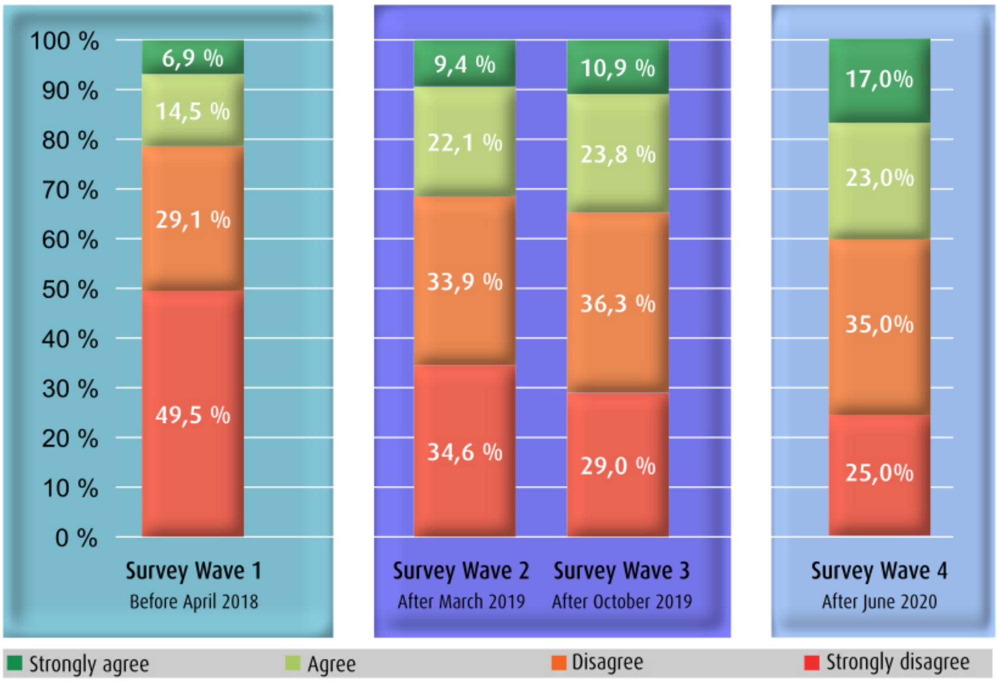


Illustration 30: Percentages of respondents living in rural areas according to their level of subscription to the measure and survey waves: wave 1 (April 2018), wave 2 (March 2019), wave 3 (October 2019), wave 4 (June 2020)

For respondents living in cities with fewer than 20,000 inhabitants (illustration 31) the proportion of people who strongly disagree with the measure fell from 46% in wave 1 to 28% in waves 2 and 3 (wave 1/wave 2, Chi 2=58.4; p=1.3 e-12; Chi 2=41.3; p=1.3 e-10).

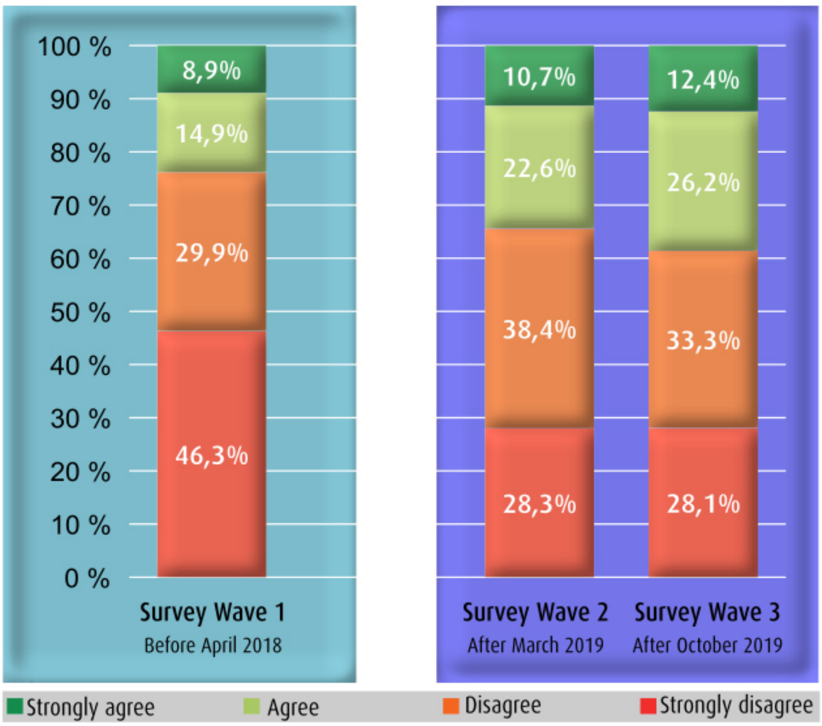


Illustration 31: Percentages of respondents living in cities with less than 20,000 inhabitants according to their level of subscription to the measure and survey waves: wave 1 (April 2018), wave 2 (March 2019), wave 3 (October 2019)

8.2 - Three-quarters of users report complying with the measure.

As of October 2019, **75% of respondents report complying with the measure “always” or “mostly”.** Before implementation of the measure, 77% of respondents gave the same type of response (illustration 32).

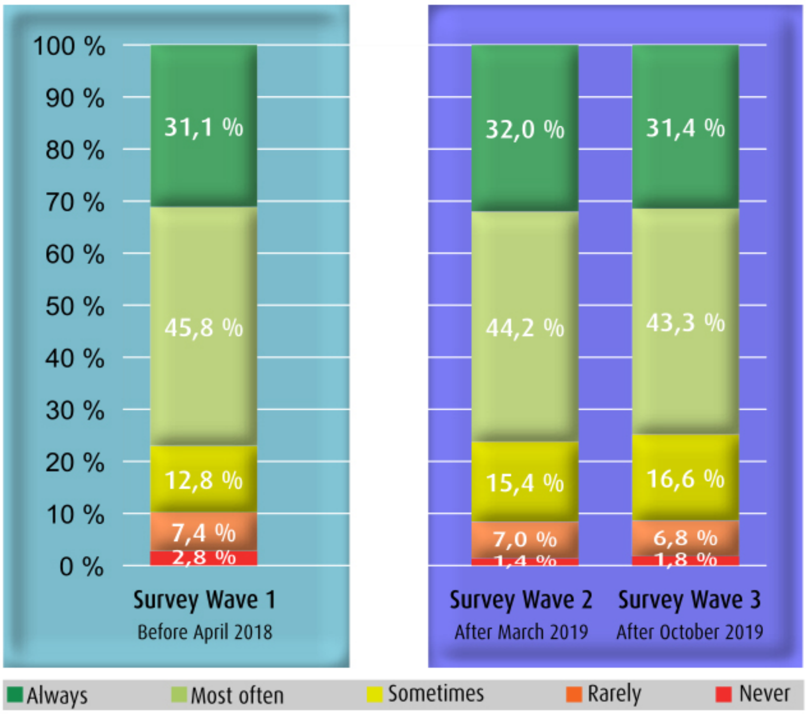


Illustration 32: Proportion of declarations of level of compliance (systematically, mostly, sometimes, rarely or never) for each of the three survey waves

Quite logically, those who are “very much in favour” of the measure are those who, for the most part, declare that they systematically comply with it (illustration 33). Conversely, those who strongly disagree with the measure tend to say that they never, rarely or only sometimes comply with it.

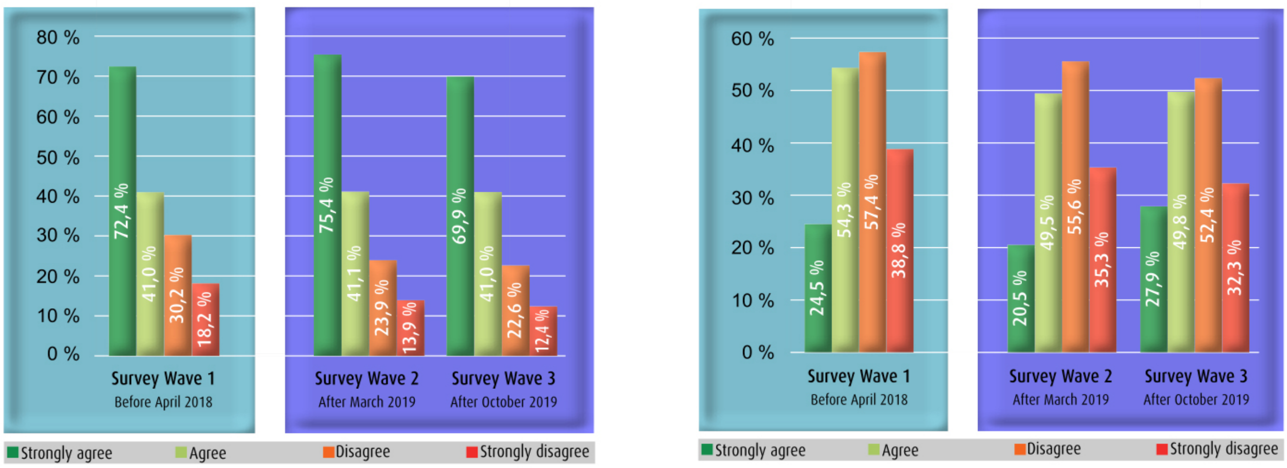


Illustration 33 : Proportion of respondents reporting subscribing to the measure systematically (left) or mostly (right) depending on the extent to which they subscribe to the measure and on the survey waves

It is interesting to note that 55% and 51% respectively of respondents who “disagree” and “agree” with the measure reported complying with it most often. This difference is statistically significant (Chi2=5.66; p=0.02), meaning that the people who “disagree” are more likely to report complying with the measure than the perople who “agree”.

80% of those who say they “disagree” to the measure say they respect it systematically or mostly.

It should be noted, however, that for the purposes of this assessment, “respecting the speed limit” does not mean driving at 80 km/h for all respondents. **They consider, on average, that they are respecting the limit when driving below 86 km/h.** The higher the level of subscription to the measure, the lower the figure. For those who “strongly agree” with the measure, it is 84 km/h. For those who “strongly disagree” it is 89 km/h (F(3; 3800)=52.94; p=.00, all the post-hoc tests are significant). These results confirm the previous studies discussed in section2.3. .

This result can be compared with the fact that almost half of the respondents consider that exceeding the speed limit by 10 km/h on this type of network has little or no impact at all on accident risk. This latter analysis is consistent with the literature review in part 2.3 which pointed out that exceeding the speed limit by 10% was considered by users as not very dangerous and not very reprehensible. However, the literature has clearly shown the difference in the impact on accident rates between driving at 80 km/h and driving at 90 km/h, and the effect of exceeding the limit by 10 km/h on French road deaths (see also appendix 2 - Elementary dynamics and practical consequences). **Road users underestimate the danger of speed.**

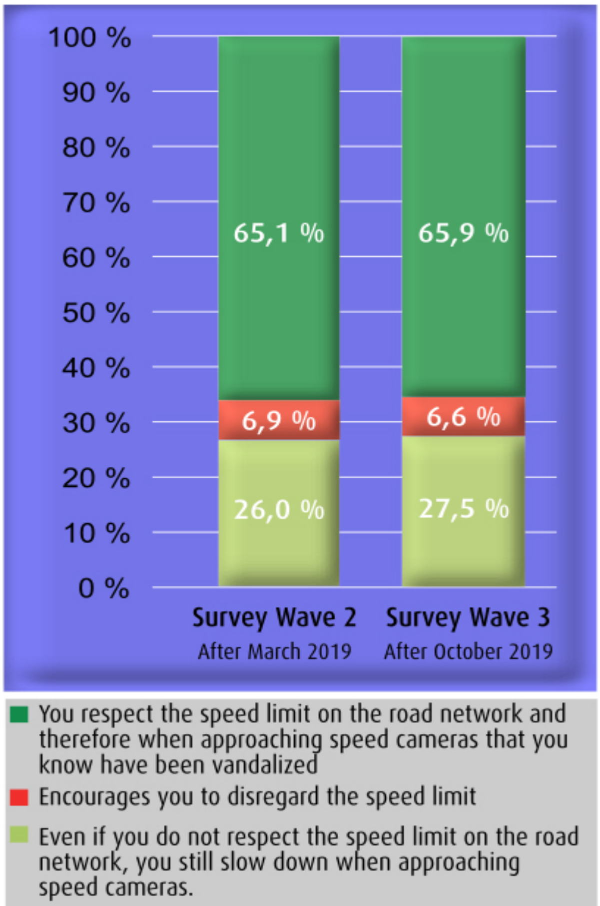


Illustration 34: Identification of behaviour when approaching vandalized speed cameras, after implementation of the measure (wave 2 in March 2019 and wave 3 in October 2019)

A question added in survey waves 2 (March 2019) and 3 (October 2019) of concerned the behaviour of respondents in the vicinity of vandalized speed cameras (illustration 34). A very small minority stated that the fact that speed cameras had been vandalised encouraged them to break the speed limit (6.9% in wave 2 and 6.6% in wave 3). On the other hand, a large majority declare that they respect the limit independently of this (65.11% in wave 2 and 65.9% in wave 3) and a quarter state that they slow down when approaching vandalised speed cameras (25.9% in wave 2 and 27.5% in wave 3).

Their declaration that they do not change their behaviour can be seen in the observation of speeds, which remain stable during this period. (part 4.2).

8.3 - Reducing the accident rate: a positive factor in subscribing to the measure

One question sought to determine whether the impact of the measure has an impact on its attitude. To do this, respondents were asked to position themselves on a 4-point scale on each of the items dealing with impact. There are no major changes between waves and results are presented for wave 3 (October 2019).

First of all, **the impact of the measure has a strong influence on the acceptability/acceptance of the measure**, since it explains 52.2% of the opinion. [R^2 ajut=0,52 ; $F(21, 2553)=134,61$; $p<0,00000$]. The model remains highly predictive with 52.2% of the variance explained.

Generally speaking, even if the coefficients are low, **subscription to the measure is supported by the arguments about reducing the accident rate** (reducing the number of deaths, severity, number of accidents, and situations such as running off the road and frontal impacts). Environmental arguments, on the other hand, are among those that carry the least weight.

Two arguments actually appear to have a negative impact on subscription to the measure:

- increasing the risk of being fined (ß=-0.12; t=-7.41; p=0.000),
- damaging gearboxes, as they are not designed to run at 80 km/h.(ß=- 0.087 ; t=-5.77 ; p=0.000).

Seven arguments appear to have a positive impact on subscription to the measure:

- reducing the number of deaths (ß=0.15; t=5.3; p=0.000),
- reducing the number of material accidents (ß=0.16; t=6.13; p=0.000),
- reduce the risk of collision because the field of vision will be smaller (ß= 0.09; t=4.12; p=0.000),
- making traffic more fluid (ß=0.08; t=3.74; p=0.000),
- reducing the severity of accidents (ß= 0.06; t=2.42; p=0.01),
- reducing head-on collisions (ß=0.06; t=2.70; p=0.007),
- reducing the number of road departures (ß= 0.06; t=2.92; p=0.004).

It is interesting to note that the risk of increasing dangerous overtaking was seen as having a negative impact on subscription to the measure in survey waves 1 and 2. However, this argument has no impact in wave 3. Respondents may have found that lower speeds on two-way roads without a central separator did not affect overtaking accidents, as confirmed by the results of the accident analysis (part 5.4.1).

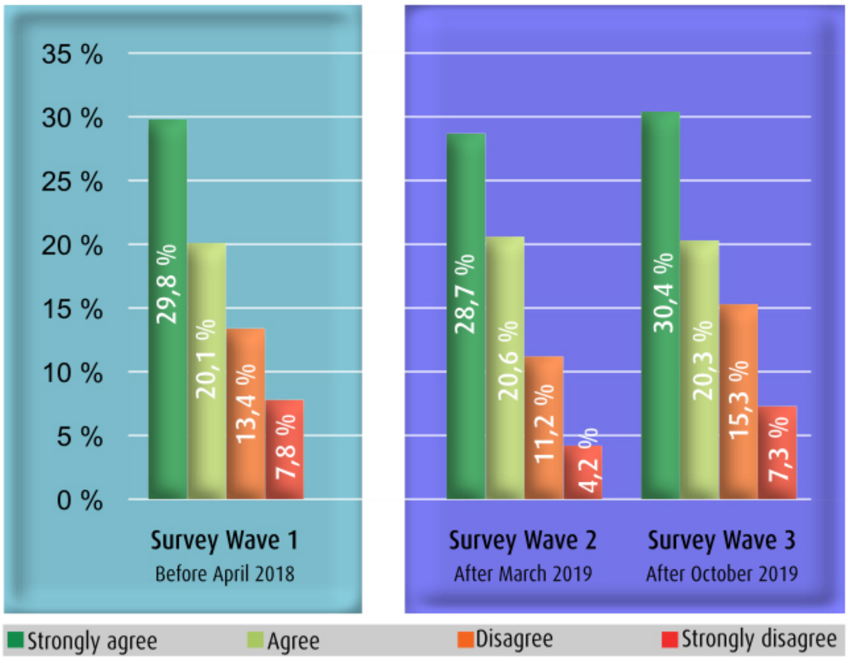


Illustration 35: Percentage of respondents thinking that speeding is a factor in accidents, depending on the extent to which they subscribe to the measure and by survey wave

On the other hand, the perception of exceeding the speed limits as a cause of accidents divided respondents between those in favour and those against the measure. This is because a small proportion of those opposed to the measure consider speeding as a cause of accidents (see illustration 35). This provides legitimacy for their failure to comply with the speed limit.

Moreover, the main arguments given by those who say they have little intention of complying with the measure are that the road allows them to go fast and that there is little risk because they are in control of their vehicle.

8.4 - Lost time estimated by users remains higher than the reality

Prior to implementation of the measure, lost time was overestimated by users. 72% of respondents felt that their travel time would be longer after July 1, 2018. For 31%, the additional travel time would be between 5 and 10 minutes, for 13% it would be more than 10 minutes.

After implementing the measure, for all types of respondents, the estimated lost time decreased compared to their projections before July 2018 (illustration 36).

The more respondents are in favour of the measure, the less they think the measure makes them lose time. This effect is constant between the 3 survey waves.

In terms of changes between waves, all respondents except those who “strongly disagree” with the measure estimate their lost time to be less in waves 2 and 3 than in wave 1. However, there is no difference between wave 2 and wave 3, except for those who strongly agree with the measure, who estimate their lost time as less in wave 3 than in wave 2.

Respondents who “disagree” with the measure estimate on average that the measure causes them to lose at best less than 2 minutes, and at worst between 2 and 5 minutes on their usual journey. Before the measure was implemented, they estimated that they would lose at best less than 5 minutes, and at worst between 5 and 10 minutes.

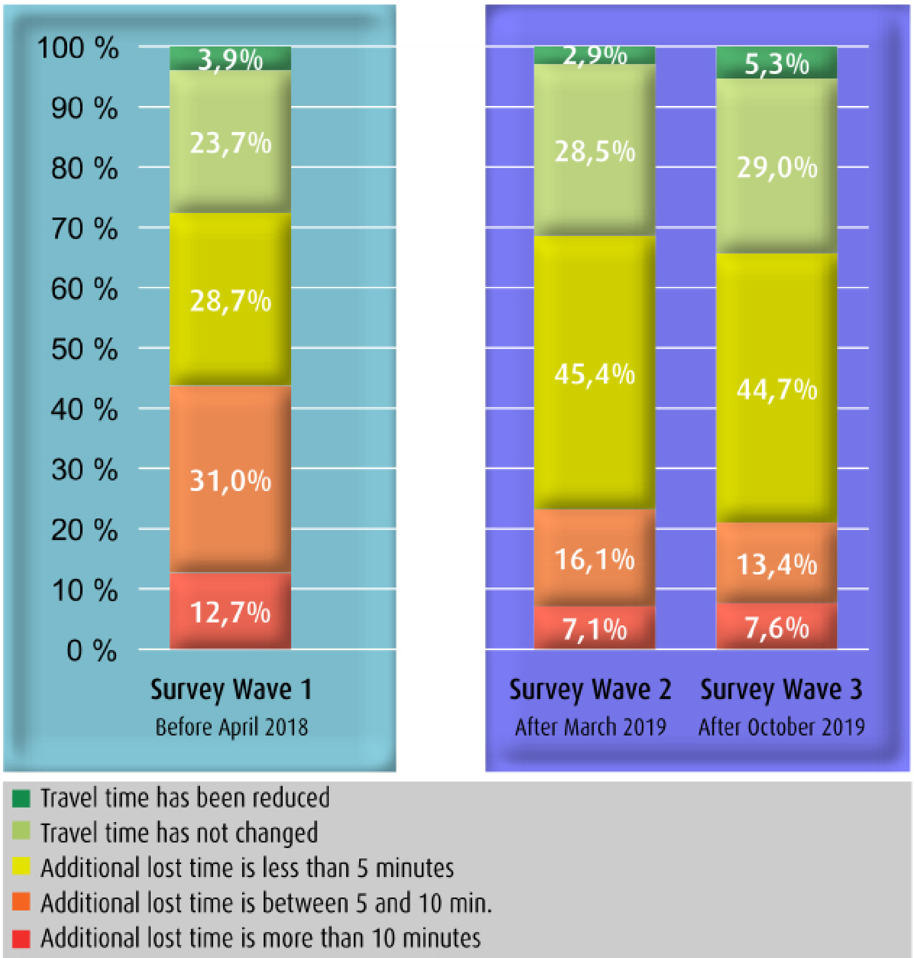


Illustration 36: travel time estimated by all respondents for each of the survey waves: wave 1 (April 2018), wave 2 (March 2019), wave 3 (October 2019)

However, the estimated lost time is still higher than the reality. The majority of users, reporting a loss of more than 2 minutes of travel time, make daily trips of less than 50 kilometres. Considering the average change estimated through travel time readings of 1 second per kilometre, travel times should be increased by about 50 seconds, which is much less than the more than 2 minutes reported.

9 - Socio-economic calculation

In this part, the indicators of the socio-economic assessment (road safety, travel time, fuel consumption, GHG emissions and investment cost) are presented, specifying the methodology applied, the data required for its application and the quantitative and monetary results.

As seen in part 3.4, the measure is taken to be a modification of the transport network. The implementation date of the project is taken as identical on all routes, i.e. 1 July 2018.

The balance sheet is based on a cost-benefit analysis comparing the before/after situation. The analysis is carried out on the basis of the difference in calculated costs between the full years 2017 and 2019.

Monetarisation of the indicators is based on reference values expressed in €2015 in the year 2015 in the sheets of the transport project assessment reference repository. Monetary indicators are therefore expressed in €2015.

The reference values are considered constant between 2017 and 2019. They concern the structure of the vehicle fleet, traffic costs, energy expenditure, etc. The reference values updated to the year 2018 will be used in the calculation of the indicators for the years 2017 and 2019.

The simplified economic balance is one excluding tax, without taking into account the public fund opportunity coefficient (COFP), and without quantifying profit and loss per actor.

9.1 - Estimated traffic considered in kilometres travelled

In the parameters for the economic calculation for the considered network at 80 km/h, it is essential to quantify the number of kilometres travelled on which the effect of the measure is to be assessed and on which the calculation of the indicators will be based. The aim is to know how many kilometres were travelled on the network examined in the assessment, i.e. that excluding “urban areas” and “motorways” (see section 3.2.2 for more details).

First of all, **it is important to remember that there are no reliable, aggregated and complete data on traffic on the network examined in the assessment. An estimate must therefore be made.**

The number of vehicles on the routes is considered to be the same in both 2017 and 2019: no change in demand is applied and route and modal shifts are considered negligible. The CGDD cost-benefit analysis (2018) supports this hypothesis by showing that the effects of modal shifts on the motorway network are small.

An initial estimate of the traffic on the considered network was made on the basis of modelling. The data from the CGDD calculations according to MODEV[26] (2018) are used. The network studied by CGDD is more extensive than the considered network. The breakdown of traffic proposed by CGDD makes it possible to identify the traffic over a whole made up of the network of national roads (RN), departmental roads (RD) and “other” roads[27]. The traffic is then 329 billion vehicles.km.

Based on the distribution of speeds by type of network (CGDD, 2018), it appears that the speed on this “other” network is 49.4 km/h. The “other roads” network is therefore more of an urban area-type network and represents around 33-34% of the total network. By removing the proportion of the urban area network from the national (RN), departmental (RD) and “other” roads, an initial hypothesis of 220 billion kilometres of traffic on the considered network can be put forward.

[26]MODEV: National transport flow model

[27]The data are not available more finely broken down.

A second estimate was made based on fuel consumption. For this purpose, the national transport accounts published by the CGDD were used. These accounts provide a traffic index by major network type. Here again, the breakdown does not make it possible to target the considered network directly. A set of national roads (excluding urban expressways and interurban roads with motorway features), departmental roads and the local network can be extracted. It has a traffic volume of 421 billion kilometres travelled (see table 1). By taking the above “urban area” proportion of 33-34% and deducting it from this total traffic volume, a second hypothesis for traffic on the considered network of 280 billion kilometres travelled can be proposed.

The traffic on the considered network is therefore approximately between a low hypothesis of 220 billion kilometres travelled, and a high hypothesis of 280 billion kilometres travelled.

The calculation of the indicators relating to increased travel time and fuel savings is based on travel times and speeds reconstructed from the FCD input data collected over the length of 3,983 km (see part 6.2) and extrapolated from the kilometres travelled on the considered network. For these two indicators, the high (280 billion) and low (220 billion) hypotheses are used to frame the results of the economic calculation.

This method assumes that the increase in travel time is proportional to the number of kilometres travelled. The method then leads to an increase in the calculation of lost time.

9.2 - Gains related to road safety

This part of the appraisal is based on changes in the number of deaths, hospitalized injuries and minor injuries[28] between the full years 2017 and 2019.

The data are those of the BAAC, data validated for both years (part 3.2.1). Raw data on the numbers of deaths and injuries are available in appendix 4.

As discussed in part 3.2.3, the breakdown between hospitalized injuries (HI) and minor injuries (MI) cannot be derived directly from the validated BAAC data. The 2017 HI/MI rate is used as a benchmark and applied to the actual number of injuries in 2019. This rate was 55.2% for those hospitalized and 44.8% for those slightly injured.

Table 12 summarizes the changes in the number of deaths, hospitalized injuries and minor injuries between 2017 and 2019, calculated according to the assumptions described above.

	Difference between 2017 and 2019
Number of deaths	- 216
Number of hospitalized people	- 1 165
Number of minor injuries	- 945

Table 12: Variation in the number of HI and MI deaths between 2017 and 2019 (Source: Official BAAC and calculation for the HI/MI rate)

[28]Mild injuries are those sustained by victims who received medical attention but were not hospitalized or were hospitalized for less than 24 hours.

The effect on road safety is monetarised by applying the reference value defined as the Statistical Value of human Life (SVL).

This insecurity reference value is expressed in €2015 in 2015[29]. It can be broken down as follows:

- Deaths (SVL: statistical value of life) = €3,200,000
- Hospitalized injuries (12.5% of SVL) = €400,000
- Minor injuries (0.5% of SVL) = €16,000

The insecurity figures change over time as does GDP per capita. Monetary gains therefore take into account changes in GDP per capita.

Mild injuries are those sustained by victims who received medical attention but were not hospitalized or were hospitalized for less than 24 hours.

The results shown in the table show an annual monetary gain of €1.2 billion for road safety (2015 value).

Annual road safety benefits (€2015 million)	
Benefits related to the number of lives saved	708.5
Benefits related to the number of hospitalized injuries prevented	477.7
Benefits related to the number of minor injuries avoided	15.1
Total benefits	1,201.3

Table 13: Annual benefits (in €2015 million) related to road safety (Source: Cerema calculation, 2020)

9.3 - Losses related to travel time

The calculation for the increase in travel time is based on the travel times and speeds reconstructed from the FCD input data collected over the 3,983 km of roads.

For each route, a global annual lost time is calculated, based on the time periods presented in part 6.2 and the different days of the week (a distinction is made between weekdays and weekend).

For each hourly period, the time lost is considered. For example, during the morning rush hour (MRH):

$$TimeLost_{MRH} = (TimeLost_{before} - TimeLost_{after})_{MRH} \; x \; Traffic_{MRH}$$

[29] fact sheet “prescribed reference values for the economic calculation”, version of 03 May 2019

Morning rush hour traffic is calculated from the average daily traffic and the proportion of GPS tracks on the time slot compared to the total daily GPS tracks.

All the results calculated per time slot are summed to obtain an average daily loss of time per route.

A global annual time lost is then calculated by multiplying the total daily lost time obtained by origin-destination by all the days of the year.

In the end, the annual travel time increase for the socio-economic calculation is calculated by subtracting the 2019 travel time (TT) from the 2017 travel time (TT). This is then reduced to the annual number of vehicles on the route to obtain an annual loss of travel time per route.

The calculation of annual losses of total travel time is obtained by summing the results obtained for each route:

$$Annual\ Loss\ of\ TimeTravel(Veh.h) = \sum_{routes} (TimeTravel\,2019 - TimeTravel\,2017)\, x Nb \frac{Veh}{day}\, x\, 365$$

The calculation of the effects of the measure on road users' travel times of requires a vehicle occupancy rate to be applied. This is taken to be 1.3 in the socio-economic calculation[30].

Travel time losses are then adjusted for the number of vehicles travelled according to the low and high traffic hypotheses. Table 14 presents the results obtained.

Difference between 2017 and 2019	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Change in travel time (millions of vehicles.hour)	+ 60.7	+ 77.2
Change in travel time (millions of users.hour)	+ 78.9	+ 100.4

Table 14: Change in journey times between 2017 and 2019 according to traffic hypotheses (Source: Cerema calculation, 2020)

The monetization of increased travel time is obtained by applying a value of time to the travel time losses quantified per million users.hours. The value of time can be defined as the maximum amount the user is willing to pay to save an hour of travel time.

$$Annual\ Loss\ of\ TimeTravel\ for\ VehUsers(€) = Annual\ Loss\ TimeTravel(VehUsers.h)\, x\ VoT$$

The proposed value of time (VoT) is the reference value in an interurban environment[31], for all reasons, calculated for distances of 20 km - 80 km, i.e.: VoT = = 0.096x d + 6.5

[30]Hypothesis based on an exploitation of the unified base of the Cerema certified national mobility surveys (EMC²) of 2017 which shows that the occupancy rate is on average 1.36 whatever the reason for the journey, and for trips to and from urban centres from and to the zone around large urban areas it is 1.3.

[31]in €2015/h per traveller in 2015 (fact sheet "*valeurs de référence prescrites pour le calcul économique*" (prescribed reference values for economic calculation), version of May 3, 2019)

Distance d is equal to the average length of the selected routes within the perimeter of the FCD data collection (around 25 km), which gives a value of time of €8.9 in 2015 per traveller.

Users' value of time changes over time as does GDP per capita. Monetary gains therefore take into account changes in GDP per capita.

The results presented in table 15 show an annual monetary loss of between €721 and €917 million for journey times.

	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Annual travel time losses (€2015 million)	- 720.9	- 917.5

Table 15: Annual losses (in €2015 million) related to travel time (Source: Cerema calculation, 2020)

9.4 - Gains in fuel consumption

It should be remembered that the socio-economic calculation is based costs excluding tax.

The amount of fuel consumed per vehicle is calculated from the volume of vehicles on a route and their fuel consumption. Fuel consumption is directly related to vehicle speeds. It also depends on the structure of the fleet and how it changes, and is differentiated by fuel type.

The assessment reference system recommends using the COPERT 4 graphs to estimate vehicle consumption as a function of their speed. The tool-kit "Framework of the reference scenario" of the assessment reference frame in force provides all the hypotheses relating to changes in the fleet and its unit fuel consumption.

The average speeds recorded by FCD traces on the restricted network applied to the kilometres travelled that have been estimated on the extended network may possibly be used.

By taking the characteristics of the 2018 fleet and considering them constant between 2017 and 2019, it is then possible to estimate the difference in the amount of fuel consumed between the situations before (2017) and after (2019) the measure is put into service for each route. These variations in the amount of fuel consumed are then reduced to the year and summed to obtain a variation over all the routes studied:

$$\Delta\, Annual\, fuel\, consumption = Nb\, Liters\, Veh\, 2019 - Nb\, Liters\, Veh\, 2017$$

with: $$Nb\, Liters\, annual\, consumption = \sum_{routes} consumption\, veh\,(Liter/km)\, x\, Nb \frac{Veh}{day}\, x\, 365\, x\, Length\,(route)$$

The variations in fuel consumed, calculated on the basis of the length collected by processing the FCD, are then adjusted for the number of kilometres travelled according to the low and high traffic hypotheses. Table 16 gives the results

Difference between 2017 and 2019	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Change in the amount of fuel consumed (millions of litres)	- 458	- 583

Table 16: Change in the amount of fuel consumed between 2017 and 2019 according to traffic hypotheses (Source: Cerema calculation, 2020)

By applying the 2018 unit prices for fuels proposed in the "Framework of the reference scenario" tool-kit, the amount of fuel saved between 2017 and 2019 is monetized.

The results presented in table 17 show an annual monetary gain of between €251 and €320 million for the fuel consumed.

	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Annual benefits related to the amount of fuel saved (€2015 millions)	+ 251.8	+ 320.5

Table 17: Annual benefits (in €2015 million) related to fuel savings (Source: Cerema calculation, 2020)

9.5 - Gains in greenhouse gas (GHG) emissions

The amount of GHG emissions is estimated from vehicle fuel consumption which is related to vehicle speeds and is calculated by applying the COPERT 4 graphs as explained in the previous paragraph. It also depends on an emission factor assigned by type of vehicle, the structure of the fleet and how it changes.

The change in the annual amount of GHGs emitted, expressed in kg/year, is calculated as the difference between the amounts emitted in 2017 and 2019. The annual quantities emitted in 2017 and 2019 are calculated by summing the individual results for each route.

$$\Delta\, Annual\, GHG\, emission = Nb\, kg\, Veh\, 2019 - Nb\, kg\, Veh\, 2017$$

with: $Nb\, kg\, annually\, emitted = \sum_{routes} consumption\, Veh\, x\, Nb \frac{Veh}{day}\, x\, 365\, x\, emission\, factor\, x\, Length(route)$

The changes in the annual amount of GHG emissions are calculated on the basis of the length data collected by processing the FCD. These must then be adjusted to the scale of the network where the measure is applied, on the number of kilometres travelled according to the low and high traffic hypotheses. Table 18 gives the results.

Difference between 2017 and 2019	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Changes in the annual amount of GHGs emitted (10^3kg)	- 1,026.0	- 1,305.8

Table 18: Changes in the amount of GHGs emitted between 2017 and 2019 according to traffic hypotheses (Source: Cerema calculation, 2020)

The variation in the quantity of GHGs emitted is monetized by applying the cost per ton of CO2, the reference value recommended by the assessment reference frame and set at €2015 53 per ton of CO2 in 2018.

The results shown in table 19 show an annual monetary gain of between €54 and €65 million for GHGs.

	Low traffic hypothesis (220 billion km)	High traffic hypothesis (280 billion km)
Annual advantages related to GHG emissions (in €2015 millions)	+ 54.4	+ 69.2

Table 19: Annual benefits (in €2015 million) related to GHG emissions (Source: Cerema calculation, 2020)

9.6 - Investment costs

The costs taken into account are:

- the annual cost of changing road signs for national and departmental roads (10-year service life)
- study and communication costs for implementing the measure.

Regarding the cost of changing the road signs, not all of them have been changed. This is because, due to the change in the French highway code to take account of the change to 80 km/h on all two-way roads without a central separator, it was not compulsory to change the signage except in the case of areas where it was decided to keep some sections at 90 km/h (e.g. overtaking areas).

The cost of the changed road signs amounts to €2.30 million in 2019, which in 2015 was €2.10 million (source: ONISR). Taking into account the life span of this type of equipment, which is estimated to be 10 years, **the annual cost taken for the road signs in the monetized analysis is €2015 210,000.**

Study and communication costs are estimated by ONISR at €6 million.

9.7 - An overall positive socio-economic balance of around €700 million

The socio-economic balance of the measure is positive. It may be considered as approximately €700 million over one year. The benefits to society mainly lie in an improved accident rate (€1.2 billion). They are consistent with the expected effect of the measure.

Monetarised socio-economic balance: sum of benefits in €2015 millions	*Low traffic hypothesis on the considered network*	*High traffic hypothesis on the considered network*
Lives saved	*708,5*	*708,5*
Hospitalized injuries prevented	*477,7*	*477,7*
Minor injuries prevented	*15,1*	*15,1*
Accident rate Balance	*1201,3*	*1201,3*
Lost time Balance	*-720,9*	*-917,5*
Fuel saved Balance	*251,8*	*320,5*
Balance of CO2 emissions prevented	*54,4*	*69,2*
Annual costs of road signs (10 years)	*-0,2*	*-0,2*
Communication costs	*-6,0*	*-6,0*
Sum of costs	*-6,2*	*-6,2*
Total	*780,3*	*667,2*

Table 20: Calculation of the total socio-economic balance from the annual balance sheets on road safety, journey times, environment and costs related to the measure (Source: Cerema calculation, 2020)

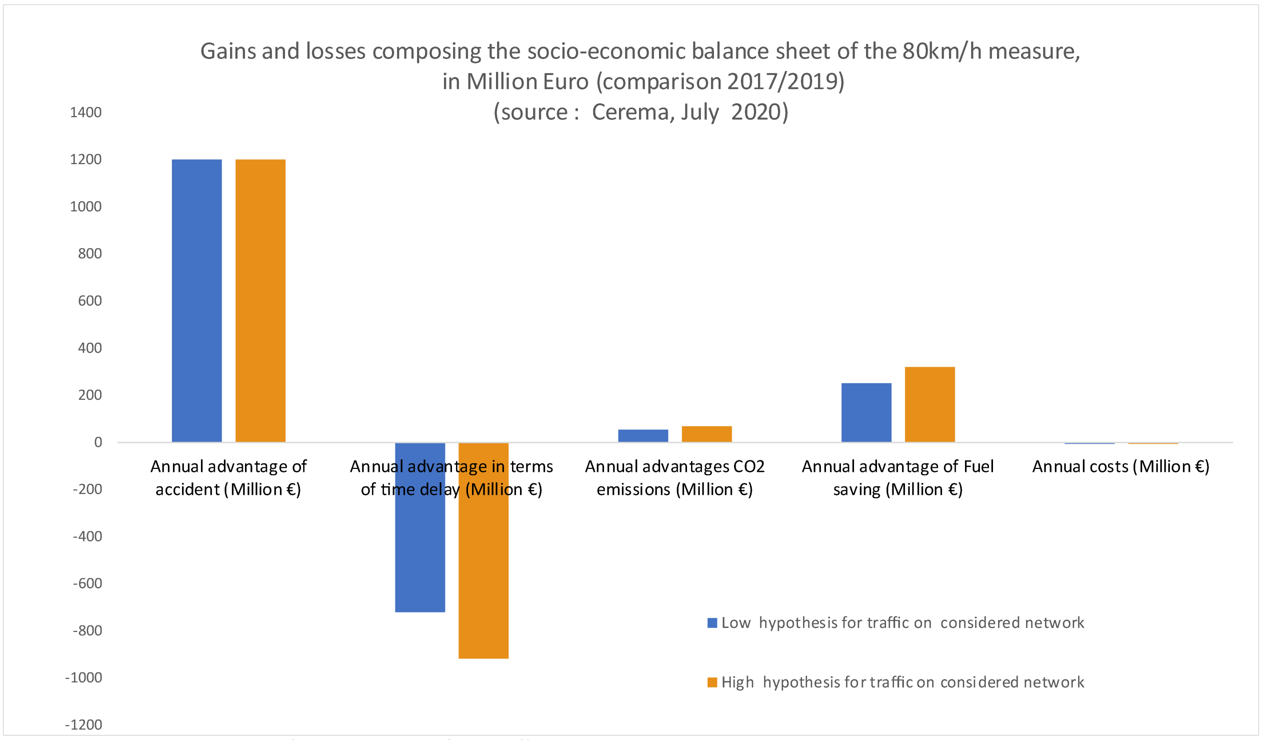


Illustration 37: Representation of the weights of the different items studied in the socio-economic calculation according to the low traffic hypothesis (series 1) and the high traffic hypothesis (series 2) (Source: Cerema calculation, 2020)

Loss of journey time is the main social cost of the measure (between €720 and €920 million), which is largely offset by the reduction in accidents, with a positive balance (between €280 and €480 million).

This positive balance is further marked by the benefits of lower fuel consumption and lower CO2 emissions. The balance sheet shows that the gains for users in terms of fuel consumption are significant (between €250 and €320 million). In terms of GHG emissions, the balance sheet shows a gain of €50 to 70 million. The gains in terms of noise and air quality, although slightly positive, are considered negligible and have not been monetized.

The balance sheet therefore shows that the measure is definitely efficient, with low investment costs and positive results in terms of achieving benefits to society in relation to social costs.

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Appendix 1 - Mission assessment questions

The DSR's mission letter to Cerema (27 April 2018) specified the questions to be answered by the assessment conducted by Cerema (in italics) and the related indicators:

Question about effectiveness: *the evaluation should reflect the reality of the reduction in speeds on the roads affected by the measure*

- the average speeds on the roads affected by the measure have fallen significantly,
- excessive speed on the roads concerned is noticeably reduced;

Question about efficiency: *to what extent does lowering the speed limit to 80 km/h on two-way roads provide an incentive to reduce the average speed?*

- road users on the two-way roads affected by the measure were targeted by the communication campaigns,
- the speed risk is understood by the users of the road affected by the measure,
- the driving behaviour of users has changed (calmer driving),

to what extent does lowering the speed limit to 80 km/h on two-way roads contribute to the fight against excessive speeds?

- the new speed limit is respected,
- the difference between the speed limit and the excess average speeds has been reduced,

to what extent does lowering the speed limit to 80 km/h on two-way roads contribute to lower accident rates?

- the number of injury accidents on two-way roads has been reduced,
- the severity of injury accidents on two-way roads has been reduced,
- the number of fatal accidents on two-way roads has been reduced;

Questions about relevance: *to what extent does lowering the speed limit to 80 km/h on two-way roads really help to solve the problem of the speed factor in road accidents?*

To what extent does lowering the speed limit to 80 km/h on two-way roads initiate a cultural change in road users' attitudes towards speed?

- awareness of speed as a risk factor is greater,
- a cultural change has been observed among all categories of users and all age groups.

On October 2, 2018 Cerema told the DSR that it could only partially address the following indicators:

- road users on the two-way roads affected by the measure were targeted by the communication campaigns,
- the driving behaviour of users has changed (calmer driving).

Appendix 2 - Elementary dynamics and practical consequences

A 2.1 - Time, speed, acceleration

A moving vehicle, like any moving object, is described at a given time t by its position x(t). The following notions derive from observing the object between two very close times t and t+dt:

- speed V(t), corresponding to the distance travelled during dt: $V=\frac{dx}{dt}$ (1)
- acceleration $\gamma(t)$ corresponding to the speed variation during the same time dt:

$$\gamma(t)=\frac{dv}{dt}=\frac{d^2x}{dt^2} \quad (2)$$

Some reference values:

- a body in free fall in a vacuum on Earth undergoes a constant acceleration noted g which is equal to 9.81 m/s^2. This means that every second its speed increases by 35 km/h.
- a sports car that accelerates from 0 to 100 km/h (27.8 m/s) in 7s therefore undergoes an acceleration of 4m/s^2
- deceleration during normal braking is 1.5 m/s^2
- the maximum permissible braking for a bus in service with standing passengers is 2 m/s^2
- the deceleration of a normal stop is 3 m/s^2, and of an emergency stop, 4 m/s^2
- the maximum permissible transverse acceleration during cornering is 3m/s^2

A 2.2 - Road dynamics

The main thing to remember is that the energy developed by a moving object varies as the square of its speed. A moving object that moves twice as fast acquires four times as much energy.

While both intuition and linearly graduated tachometers lead us to believe it, the same speed difference does not correspond to the same energy difference but depends on the speed at which the difference is measured.

For a 1500kg vehicle, a difference of 10km/h therefore represents an energy difference of:

- 5.8 kilojoules between its position at rest and when travelling at 10 km/h.
- 144.5 kilojoules when it goes from 120 km/h to 130 km/h

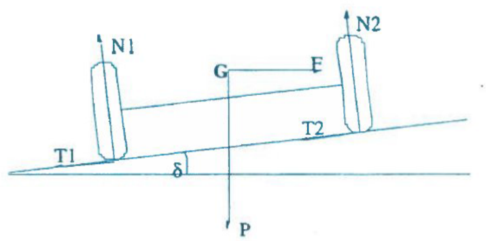
The same speed difference thus corresponds to an energy 25 times greater. This explains the high power required for vehicles reaching high speeds, and the high fuel (energy) consumption at high speeds.

The same applies to the longitudinal kinetic energy E of a moving body of mass m moving at speed V:

$$E=1/2\,m\,v^2 \quad (3)$$

The same applies to the transverse force F which a vehicle of mass m undergoes in a crossfall δ of radius R with a gradient which corresponds to the energy required to be absorbed by the suspension and the frictional forces of the tyres to keep it on the road:

$$F=m\frac{v^2}{R} \quad (4)$$



With what we have seen above, this means that the critical cornering speed, beyond which equilibrium is no longer assured and the vehicle goes off course, is a function of the maximum permissible transverse acceleration $\gamma_t = 3$:

$$V_{cr} = \sqrt{(\gamma_{tmax} R)} = \sqrt{(3R)} \quad (5)$$

A 2.3 - Physical laws and braking

A 2.3.1 - Steps in the sequence of events leading up to braking

Faced with a given situation in which he has to stop, the sequence of events for the driver is divided into two main stages:

- reaction time (t_r), counted from the moment when an abnormal situation, involving braking, is visible and the first action on the vehicle (steering, braking, etc.). During this period, the speed of the vehicle remains at its initial value.
- Action time (t_a), during which the driver operates the vehicle's systems, which ends either when he solves the problem (avoids the obstacle or stops the vehicle in time) or with a collision. During this period, the speed varies. For example, in the case of a stopping manoeuvre, the speed decreases according to the deceleration pattern.

Various external conditions, such as the weather, can influence these times through their influence on the interactions:

- on the interaction between the driver and the environment: when conditions lead to a reduction in visibility or identification of the situation which will thus delay the moment of decision when an event occurs: it may affect the decision to brake when an obstacle or priority sign is encountered, or the decision to steer according to a given curve. This interaction influences the reaction time.
- On the interaction between the vehicle and the road: when conditions have an effect on the structure of the tyre or the road surface acting on grip by modification of the materials (hardening of the tyres by cold, ice, rain, etc.). This interaction influences the time of action.

Driver reaction time (t_r) itself has two components: $t_r = t_d + t_i$ where:

- t_d is the “decision” time: the driver sees the situation (trigger signal), and his brain indicates that something must be done. The value of this time depends on the environment: in bad weather conditions for example, this time may be longer because the stimuli are different and the brain does not take into account the situation as quickly as in normal situations because it may not understand the context correctly at first sight (a shadow not identified as an obstacle, a glare problem on a rainy night, etc.).
- t_i is the “initiation” time: the driver's brain has understood that something must be done, order it to be done and do it. “I have to brake, I move my foot onto the pedal, my foot is now on the brake pedal”. This time is influenced by brain performance, which depends on several parameters such as age, health, alcohol consumption or medication, other external stimuli (telephone or in-car entertainment devices) and experience (an experienced driver will order faster than a new driver). It can be considered that this component depends only on the driver.

A number of behavioural studies have provided a better understanding of reactions, mainly based on laboratory studies, simulation bases or measurements in vehicles, such as research on driving in the natural environment. Such references are, for example, cited by an Australian study (Trigg et al., 1982). After a broad state of the art, the author conducts his own experiments and obtains results that show how reaction time can be highly variable, as shown in the following table:

C.R.B. "Roadworks Ahead" Sign	3.0s
Protruding vehicle with tyre change	1.5s
Lit vehicle under repair at night	1.5s
Parked Police Vehicle	2.8s
Amphometer: Beaconsfield	3.4s
Amphometer: Dandenong North	3.6s
Amphometer: Gisborne	3.6s
Amphometer: Tynong	2.54s
Railway crossing: Night (General Population)	1.50s
Railway crossing: Night (Rally drivers)	1.50s
Railway crossing: Day	2.53s
Car following	1.26s

Illustration 38: 85th percentile of reaction time values - Trigg et al. 1982

A general value of 2.5 seconds is strongly suggested by this study. But it should be pointed out that, as the author says: “The reaction time depends largely on the type of situation, the degree of urgency and the speed of the vehicle at the time the call signal begins”.

A 2.3.2 - Braking distance

Here we will be looking particularly at braking distance, i.e. the distance corresponding to the action time t_a between the moment when the vehicle starts to slow down and the moment when it stops.

One of the most conventional approaches, on which driver learning figures are based, has generally been developed, for the calculation of braking distance, by applying the following equation resulting from a uniform deceleration motion:

$$d_f = \frac{v_0^2}{2\,x\,g\,x\,(f+G)} \quad (6)$$

where:

- d_f= braking distance
- v_0= initial speed of the car (m/s)
- g = acceleration due to gravity (g =9.81 m/s^2)
- f = deceleration coefficient, tyre/road contact effect as a fraction of g =9.81m/s^2
- G = gradient (road slope) tan α (+ up; - down)

In fact, several different parameters have an impact on the coefficient f:

- first of all the initial speed itself;
- then the state of tyre-road contact, which is greatly influenced by the road surface, weather conditions or tyre characteristics (inflation, contact surface, tread, rubber, etc.).
- the characteristics of the road structure: depending on the intrinsic quality of the surfacing (such as the type and granularity: micro- and macro-texture and type of aggregate used, longitudinal evenness, etc.), braking will be more or less effective. For example, dirt and gravel roads do not provide good traction and increase braking distance;
- vehicle characteristics: suspension (keeping the tyre in contact with the road), braking systems (emergency braking assistance, ABS, etc.),

- the driver's ability to apply a given deceleration in an emergency, which depends on the driver's own abilities but also on the vehicle: ABS, for example, optimises the grip effect but also increases the deceleration allowed by the driver.

The previous model, although widely used, can therefore be considered a simplification because these latter explanatory parameters do not appear explicitly.

A more sophisticated approach was therefore explored (Patte, 2013; Patte, 2015), based on several theoretical results and using in situ measurements to calibrate the model parameters and validate the results.

The new equation used is then:

$$d_f = \frac{1}{g} \int_{v_0}^{0} \frac{v}{\gamma(v) + G} \quad (7)$$

This more complete theory introduces a new speed-dependent parameter γ, which is the instantaneous deceleration of a fraction g.

The function γ transforms the interactions and characteristics mentioned above that can have an impact on deceleration; it is composed of several parameters as explained by Patte (2013).

Basically, $\gamma = \inf(\mu, \gamma_{driver})$ where:

- μ parameter depends on braking and road characteristics, and is calculated from the formula $\mu = 0.95\ \mu_{max}$ if the vehicle is equipped with ABS, $\mu = \mu_{block}$ otherwise, where μ_{block} is a function of the water level, the LCF (Longitudinal coefficient of friction) and the tyre tread depth h_s. The LCF itself also depends on speed, according to the Pennsylvania Transportation Institute's b-parameter model: $CFL(v) = CFL(0)\ e^{bv}$.

- γ_{driver} is defined as the maximum deceleration that the driver is able to apply.

In practice, the simple equation is sufficient. It corresponds to the case where γ and G are constant and where γ is considered to be represented solely by the coefficient of friction μ.

A 2.3.3 - Stopping distance

Stopping distance consists of:

- the distance travelled during the reaction time t_r, sum of the distances travelled during the decision time t_d and the initiation time t_i. Over this distance, and during this time, the speed remains at its initial value v_0,
- the distance travelled during the action time t_a, i.e. the braking distance d_f.

This corresponds to the following equation according to the usual model:

$$s = v_0 x\, t_r + d_f = v_0 x\, t_r + \frac{v_0^2}{2 x\, g\, x (f + G)} \quad (8)$$

where

- s = stopping distance of the car (m)
- v_0= initial speed of the car (m/s)
- d_f= braking distance
- t_r = driver reaction time
- g = acceleration due to gravity (g =9.81 m/s^2)
- f = deceleration coefficient, tyre/road contact effect as a fraction of g = 9.81 m/s^2

- G = gradient (road slope) = tan α (+ up; - down)

The stopping distance of the car s can be considered as a safety braking distance:

- if an event is detected at a distance greater than this value, the vehicle will stop in time.
- if the event is detected at a distance less than this value, the vehicle will not stop in time.

According to (8), which describes a uniform deceleration movement, it is possible to estimate the residual velocity v(x) at distance x from the detection point, given that it is a uniform deceleration movement:

$$v(x)=v_0 \quad \text{if} \quad x \leq x_{reaction}$$

$$(9) \qquad v(x)=\sqrt{v_0^2-2gf(x-v_0t_r)} \quad \text{si} \quad x_{reaction} \leq x \leq s$$

$$v(x)=0 \quad \text{if} \quad x \geq s$$

where

- x = distance travelled from the point of detection
- s = stopping distance of the car (m)
- v_0= initial speed of the car (m/s)
- t_r = driver reaction time
- $x_{reaction}$ = distance travelled during reaction time = v_0t_r
- g = acceleration due to gravity (g =9.81 m/s^2)
- f = deceleration coefficient, tyre/road contact effect as a fraction of g = 9.81 m/s^2
- v(x) = speed at position x

This residual speed is a crucial assessor of the effects on road safety, as the consequences of an accident are strongly related to the speed at impact because the impact energy to be absorbed depends on its square, as seen above (see 2.2 Road dynamics).

All the concepts introduced can be illustrated as shown in the following figure.

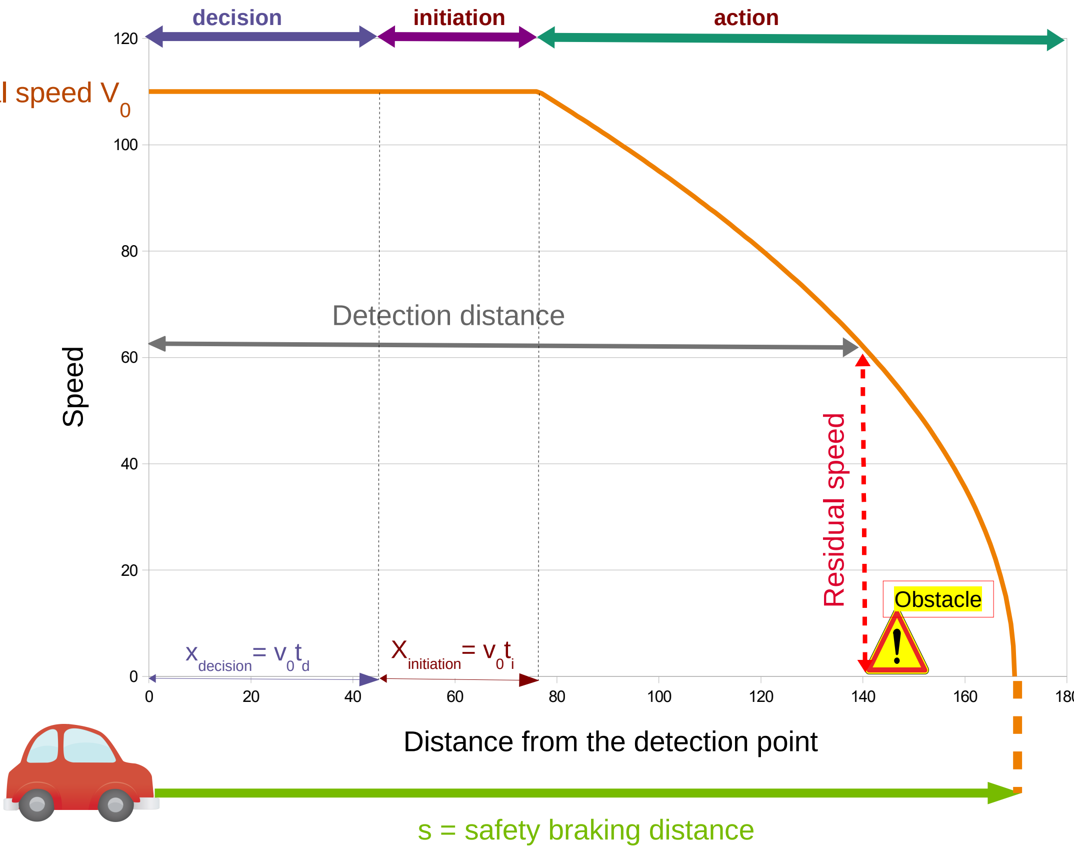


Illustration 39: Safety distance and residual speed when the vehicle strikes the obstacle

A 2.4 - Practical consequences of lowering the speed limit from 90km/h to 80km/h

A 2.4.1 - Effect on energy

By applying the equation of a movement uniformly accelerated by g, a body dropped in a vacuum on Earth with a height H reaches the velocity: $V=\sqrt{(2gH)}$ (cf. (6)).

A vehicle moving at 80km/h therefore has the same energy as if it fell from a height of 25m. At 90km/h, the height of fall increases to 32m.

A 2.4.2 - Effect on travel time and distances

By applying the equations seen above, **the maximum absolute time loss is 5 s/km:**

$$P=T_{80}-T_{90}=3600/80-3600/90=5\,s/km$$

In fact, and given that the average speed is the result of a series of hazards over a journey, the measured loss is much lower (see chapter 6 of the report).

As an illustration, if a road user travelling at 90km/h encounters a red light on arrival that lasts 2 minutes, he will be caught up by a road user travelling at 80km/h whenever his total journey is less than 24km.

In the same way, a vehicle travelling at 90km/h will gain 15 minutes only after ... 180 km

A 2.4.3 - Effect on cornering

By application of (5), the critical radius at 80 km/h is 164m. The transverse force undergone by a 1500 kg vehicle will be 4517 N according to (4), a force **corresponding** to that required to lift a mass of 460 kg, i.e. almost a third of the weight of the vehicle.

If a user approaches the same turn at 90 km/h, he will experience a tangential acceleration according to (4) of 3.8 m/s^2. This is 0.8 m/s^2 above the permissible tangential acceleration. For a 1500kg vehicle, this represents an additional force of 1200N which will not be taken up by the vehicle; this value corresponds to the force required to lift 120kg and will throw the vehicle out of the bend.

A 2.4.4 - Effect on braking

From system 9, on a flat road with zero gradient, the following parameters are selected:

- t_r = driver reaction time = 1.5s
- gf = 7 m/s^2 emergency deceleration (100 km/h in 4s)

It is therefore possible to establish the speed profile according to whether the driver is driving at 80 km/h or 90 km/h as a function of the distance from the point at which the he has detected the need to stop (illustration 40).

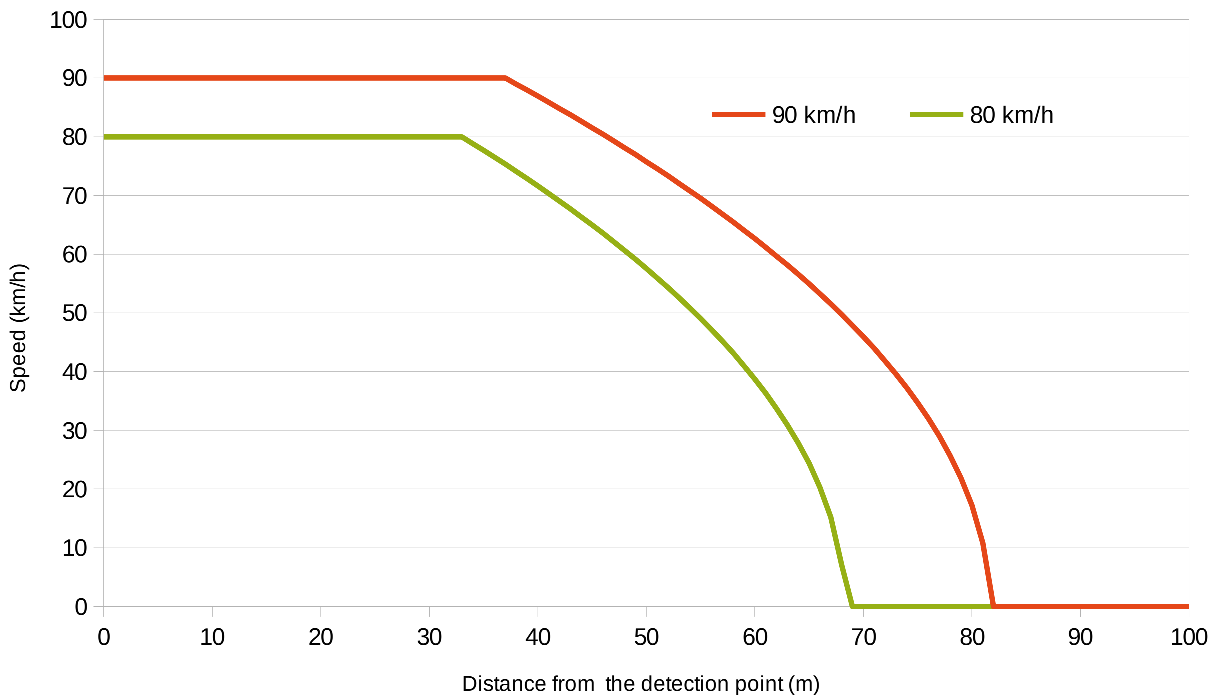


Illustration 40 : Comparative speed profiles in the event of emergency braking

It follows that:

- a driver driving at 90 km/h brakes at the same time (after 1.5 s) but 4m further than a driver driving at 80 km/h: at this same point, the driver driving at 80 km/h will already have reduced his speed to 74 km/h, i.e. 16 km/h less.
- the driver driving at 80 km/h stops in 69 m. At this point, the driver driving at 90 km/h is still driving at 50 km/h, and he needs another 13 m to stop.

Suppose the obstacle is a vehicle coming out of an intersection.

Assuming that the junction is 69 m away, this means that the driver driving at 80 km/h will stop just before the collision, while the driver driving at 90 km/h will collide with the vehicle at a speed of 50 km/h, which corresponds to a lateral crash test speed: the vehicle will be destroyed.

Worse still: if the intersection is 54m away, the vehicle initially driving at 80 km/h will hit the other vehicle at 50 km/h, the speed of a lateral crash test. But the vehicle initially driving at 90 km/h will hit the other vehicle at ... 71 km/h! At this speed, the risk of death is 30% for the occupants, and over 90% if the vehicle hits another vehicle from the side (Richards, 2010).

Appendix 3 - Data from the Cerema VMA80 speed laboratory

Monthly figures from the observatory:

	Number of vehicles	Traffic/day/site	Number of light vehicles	Number of HGVs
June-18	8300118	7700	7347665	456311
July-18	7188789	7200	6281882	422024
August -18	6776699	6300	5981608	344045
Sept-18	7424276	7000	6495520	406871
Oct-18	7539610	7100	6585632	446936
Nov-18	7437101	6900	6422630	463163
Dec-18	7265888	6400	6462494	349409
Jan-19	6679732	6200	5995123	333646
Feb-19	6693449	6800	5931996	368231
March-19	7729870	7000	6832505	415929
April-19	7705088	7300	6808880	421909
May-19	7727557	7400	6886489	410370
June-19	7399878	7600	6586598	380004
July-19	8033209	7300	6999235	490239
August -19	7276919	6900	6423547	393541
Sept-19	8085551	7600	7113318	447371
Oct-19	8110433	7300	7170478	463157
Nov-19	7724903	7100	6878286	422937
Dec-19	8065492	7200	7252925	406877

Table 21: Number of passing vehicles recorded on the 2-lane sites of the VMA80 observatory (Source: Cerema)

The table above gives the monthly speed figures on the two-lane two-way roads of the Cerema VMA80 observatory.
Changes in figures are not indicative of the change in traffic on the observatory's sites, since they are also sensitive to the observatory's operating contingencies. On the other hand, the size of the sample remains close to the total population, which makes it possible to account for changes in speeds.

Changes in average monthly speeds:

	Average speed for all users (km/h)	Average speed for light vehicles	Average speed for heavy goods vehicles
June-18	86.4	87.0	78.4
July-18	82.1	82.6	75.7
August -18	82.6	82.9	76.5
Sept-18	82.7	83.2	76.6
Oct-18	82.6	83.0	77.0
Nov-18	82.9	83.3	77.6
Dec-18	83.1	83.4	76.9
Jan-19	83.2	83.6	76.7
Feb-19	83.4	83.8	76.7
March-19	83.4	83.9	76.8
April-19	83.6	84.1	76.9
May-19	83.2	83.7	76.8
June-19	83.6	84.1	77.1
July-19	83.3	83.9	76.2
August -19	83.5	83.9	76.3
Sept-19	83.2	83.7	76.6
Oct-19	82.9	83.3	76.2
Nov-19	82.9	83.3	76.4
Dec-19	82.7	83.1	76.2

Table 22: Average monthly speeds from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Changes in speed percentiles:

	V15 (km/h)	V85 (km/h)	V85-V15 (km/h)
June-18	76	97	21
July-18	73	92	19
August -18	74	93	19
Sept-18	74	93	19
Oct-18	73	93	20
Nov-18	74	93	19
Dec-18	73	94	20
Jan-19	74	94	20
Feb-19	74	94	20
March-19	74	94	20
April-19	74	94	20
May-19	74	94	20
June-19	74	94	20
July-19	74	94	20
August -19	74	94	20
Sept-19	74	94	20
Oct-19	73	93	20
Nov-19	73	93	20
Dec-19	72	93	21

Table 23: Monthly V15 and V85 for all vehicles from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Trends in the rate at which light vehicles exceed speed limits:

Light vehicles	> 80 km/h	> 90 km/h	> 100 km/h	> 110 km/h
June-18	72.3%	35.4%	12.5%	4.7%
July-18	52.4%	20.5%	8.3%	3.2%
August -18	54.0%	21.2%	8.7%	3.4%
Sept-18	55.5%	21.5%	8.6%	3.4%
Oct-18	54.0%	21.1%	9.1%	4.0%
Nov-18	55.8%	21.8%	8.9%	3.6%
Dec-18	57.6%	23.5%	9.4%	3.7%
Jan-19	58.3%	23.6%	9.4%	3.7%
Feb-19	59.0%	23.7%	9.4%	3.6%
March-19	59.3%	24.0%	9.5%	3.7%
April-19	59.5%	23.8%	9.3%	3.6%
May-19	58.2%	23.0%	9.1%	3.5%
June-19	59.0%	24.6%	9.7%	3.7%
July-19	58.2%	24.7%	9.6%	3.6%
August -19	58.5%	24.4%	9.6%	3.6%
Sept-19	58.2%	23.6%	9.1%	3.5%
Oct-19	57.2%	22.9%	8.8%	3.4%
Nov-19	57.7%	22.8%	8.6%	3.3%
Dec-19	57.9%	23.1%	8.8%	3.4%

Table 24: Monthly rates at which LVs exceed speed thresholds from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Trends in the rate at which HGVs exceed speed limits:

Heavy goods vehicles	> 80 km/h	> 90 km/h
June-18	48.6%	7.6%
July-18	35.0%	4.1%
August -18	37.5%	5.6%
Sept-18	37.5%	4.5%
Oct-18	37.0%	5.9%
Nov-18	38.6%	5.7%
Dec-18	38.3%	4.8%
Jan-19	36.9%	4.9%
Feb-19	37.7%	3.6%
March-19	38.0%	3.8%
April-19	38.0%	3.8%
May-19	38.8%	3.8%
June-19	40.1%	4.2%
July-19	38.5%	4.1%
August -19	38.9%	4.2%
Sept-19	38.5%	4.4%
Oct-19	36.9%	4.2%
Nov-19	36.6%	4.0%
Dec-19	36.5%	4.0%

Table 25: Monthly rates at which HGVs exceed speed thresholds from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Changes in Time headway (TH) for light vehicles:

Light vehicles	TH < 2 s	TH < 1 s
June-18	25%	7%
July-18	25%	7%
August -18	22%	6%
Sept-18	25%	7%
Oct-18	26%	8%
Nov-18	25%	7%
Dec-18	24%	7%
Jan-19	23%	7%
Feb-19	25%	7%
March-19	25%	8%
April-19	25%	7%
May-19	25%	7%
June-19	25%	7%
July-19	24%	7%
August -19	23%	6%
Sept-19	25%	7%
Oct-19	25%	7%
Nov-19	24%	6%
Dec-19	24%	7%

Table 26: Proportion of short and very short THs for light vehicles in relation to the preceding vehicle from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Changes in Time headway (TH) for HGVs:

Heavy goods vehicles	TH < 2 s	TH < 1 s
June-18	6%	0.7%
July-18	7%	0.6%
August -18	6%	0.6%
Sept-18	6%	0.7%
Oct-18	6%	0.9%
Nov-18	6%	0.6%
Dec-18	6%	0.5%
Jan-19	5%	0.5%
Feb-19	6%	0.5%
March-19	6%	0.6%
April-19	6%	0.5%
May-19	6%	0.4%
June-19	6%	0.6%
July-19	6%	0.6%
August -19	6%	0.5%
Sept-19	6%	0.5%
Oct-19	5%	0.4%
Nov-19	5%	0.4%
Dec-19	5%	0.4%

Table 27: Proportion of short and very short THs for HGVs in relation to the preceding vehicle from June 2018 to December 2019, data from the VMA80 observatory (Source: Cerema)

Appendix 4 - Accident data - Raw data

A 4.1 - Number of deaths

Considered network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	158	147	158	144	141	150	138	-12	133	-17	*156*	*6*
February	139	143	142	167	129	144	121	-23	142	-2	*120*	*-24*
March	133	158	138	168	164	152	156	4	158	6	*91*	*-61*
April	149	158	160	149	173	158	178	20	134	-24	*65*	*-93*
May	122	160	170	184	192	166	170	4	146	-20	*135*	*-31*
June	188	207	186	179	208	194	193	-1	174	-20	ND	
Total first half-year	889	973	954	991	1007	963	956	-7	887	-76	ND	
July	222	201	221	230	220	219	202	-17	209	-10	ND	
August	212	205	205	197	190	202	159	-43	175	-27	ND	
September	196	196	165	212	188	191	194	3	187	-4	ND	
October	193	222	250	210	206	216	155	-61	165	-51	ND	
November	163	171	186	149	182	170	176	6	161	-9	ND	
December	203	184	194	200	168	190	177	-13	161	-29	ND	
Total second half-year	1189	1179	1221	1198	1154	1188	1063	-125	1058	-130	ND	
ANNUAL TOTAL	2078	2152	2175	2189	2161	2151	2019	-132	1945	-206	ND	

Table 28 - Number of deaths per month on the considered network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

Rest of the network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	85	88	104	92	114	97	91	-6	106	9	*104*	*7*
February	82	82	93	96	75	86	97	11	112	26	*102*	*16*
March	67	103	81	87	103	88	79	-9	97	9	*63*	*-25*
April	87	96	98	94	108	97	106	9	101	4	*38*	*-59*
May	102	100	97	110	105	103	98	-5	97	-6	*70*	*-33*
June	105	104	113	106	116	109	97	-12	118	9	ND	
Total first half-year	528	573	586	585	621	579	568	-11	631	52	ND	
July	122	101	132	126	123	121	126	5	119	-2		
August	110	101	127	104	107	110	87	-23	115	5		
September	116	121	92	122	109	112	128	16	123	11		
October	115	125	128	105	113	117	119	2	92	-25		
November	89	109	110	109	90	101	92	-9	96	-5		
December	110	102	111	137	124	117	109	-8	123	6		
Total second half-year	662	659	700	703	666	678	661	-17	668	-10		
ANNUAL TOTAL	1190	1232	1286	1288	1287	1257	1229	-28	1299	42	ND	

Table 29 - Number of deaths per month on the rest of the network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

A 4.2 - Number of injury accidents

Considered network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	905	989	925	1022	1098	988	947	-41	892	-96	*1013*	*25*
February	765	860	825	933	1021	881	816	-65	1028	147	*934*	*53*
March	841	960	975	1024	1296	1019	979	-40	1076	57	*619*	*-400*
April	938	1006	1174	1014	1418	1110	1206	96	1088	-22	*359*	*-751*
May	1006	1127	1242	1269	1444	1218	1282	64	1132	-86	*941*	*-277*
June	1273	1325	1464	1282	1645	1398	1398	0	1360	-38	ND	
Total first half-year	5728	6267	6605	6544	7922	6613	6628	15	6576	-37	ND	
July	1431	1225	1426	1473	1527	1416	1535	119	1494	78	ND	
August	1276	1153	1367	1258	1363	1283	1329	46	1384	101	ND	
September	1227	1191	1315	1328	1343	1281	1368	87	1294	13	ND	
October	1137	1250	1228	1392	1360	1273	1333	60	1296	23	ND	
November	990	1088	1142	1291	1150	1132	1134	2	1065	-67	ND	
December	1093	1053	1125	1335	1107	1143	1194	51	1091	-52	ND	
Total second half-year	7154	6960	7603	8077	7850	7529	7893	364	7624	95	ND	
ANNUAL TOTAL	12882	13227	14208	14621	15772	14142	14521	379	14200	58	ND	

Table 30 - Number of injury accidents per month on the considered network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

Rest of the network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	3354	3660	3352	3633	3322	3464	3281	-183	3085	-379	*3409*	*-55*
February	2990	3231	2884	3025	2855	2997	2523	-474	3054	57	*3010*	*13*
March	3046	3649	3298	3390	3650	3407	2995	-412	3379	-28	*1824*	*-1583*
April	3482	3819	3463	3279	3530	3515	3468	-47	3259	-256	*740*	*-2775*
May	3497	3831	3499	3698	3668	3639	3592	-47	3532	-107	*2135*	*-1504*
June	4103	4110	4064	3900	4102	4056	4022	-34	3875	-181	ND	
Total first half-year	20472	22300	20560	20925	21127	21077	19881	-1196	20184	-893	ND	
July	4078	3544	3615	3607	3621	3693	3526	-167	3793	100	ND	
August	3065	2947	2912	2908	2928	2952	2827	-125	2869	-83	ND	
September	4266	4133	3885	3927	3745	3991	4002	11	3833	-158	ND	
October	4244	4377	3857	4059	3991	4106	4168	62	3839	-267	ND	
November	3999	3967	3856	3910	3837	3914	3564	-350	3560	-354	ND	
December	3806	3696	3710	3565	3592	3674	3277	-397	3738	64	ND	
Total second half-year	23458	22664	21835	21976	21714	22329	21364	-965	21632	-697	ND	
ANNUAL TOTAL	43930	44964	42395	42901	42841	43406	41245	-2161	41816	-1590	ND	

Table 31 - Number of injury accidents per month on the rest of the network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

A 4.3 - Number of injuries

Considered network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	1222	1391	1318	1435	1529	1379	1302	-77	1226	-153	*1448*	*69*
February	1042	1198	1168	1250	1360	1204	1153	-51	1333	129	*1256*	*52*
March	1161	1274	1316	1369	1740	1372	1344	-28	1431	59	*816*	*-556*
April	1313	1354	1594	1405	1922	1518	1640	122	1471	-47	*384*	*-1134*
May	1403	1593	1651	1783	1945	1675	1803	128	1558	-117	*1137*	*-538*
June	1708	1838	1969	1827	2296	1928	1871	-57	1914	-14	ND	
Total first half-year	7849	8648	9016	9069	10792	9075	9113	38	8933	-142	ND	
July	1998	1773	2030	2125	2171	2019	2073	54	2073	54	ND	
August	1804	1681	1884	1792	1845	1801	1809	8	1927	126	ND	
September	1649	1619	1830	1759	1777	1727	1800	73	1682	-45	ND	
October	1509	1664	1643	1922	1785	1705	1726	21	1804	99	ND	
November	1264	1521	1475	1808	1569	1527	1489	-38	1426	-101	ND	
December	1441	1517	1529	1868	1592	1589	1637	48	1576	-13	ND	
Total second half-year	9665	9775	10391	11274	10739	10369	10534	165	10488	119	ND	
ANNUAL TOTAL	17514	18423	19407	20343	21531	19444	19647	203	19421	-23	ND	

Table 32 - Number of injuries per month on the considered network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

Rest of the network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	3956	4329	3942	4480	3890	4119	3899	-220	3733	-386	*4180*	*61*
February	3551	3893	3517	3589	3427	3595	2995	-600	3649	54	*3526*	*-69*
March	3717	4423	3980	4090	4416	4125	3668	-457	4069	-56	*2149*	*-1976*
April	4168	4599	4177	3949	4311	4241	4244	3	3956	-285	*863*	*-3378*
May	4275	4723	4317	4490	4422	4445	4452	7	4296	-149	*2567*	*-1878*
June	4868	5012	4888	4800	4897	4893	4844	-49	4757	-136	ND	
Total first half-year	24535	26979	24821	25398	25363	25419	24102	-1317	24460	-959	ND	
July	5019	4373	4515	4497	4624	4606	4459	-147	4719	113	ND	
August	3931	3752	3686	3671	3678	3744	3598	-146	3685	-59	ND	
September	5110	4989	4704	4771	4518	4818	4814	-4	4638	-180	ND	
October	5093	5269	4642	4933	4712	4930	4962	32	4689	-241	ND	
November	4789	4791	4547	4719	4623	4694	4314	-380	4317	-377	ND	
December	4616	4472	4480	4313	4335	4443	3991	-452	4561	118	ND	
Total second half-year	28558	27646	26574	26904	26490	27234	26138	-1096	26609	-625	ND	
ANNUAL TOTAL	53093	54625	51395	52302	51853	52654	50240	-2414	51069	-1585	ND	

Table 33 - Number of injuries per month on the rest of the network, by year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

A 4.4 - Death and injury rates per accident

Considered network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	17.5	14.9	17.1	14.1	12.8	15.1	14.6	-0.6	14.9	-0.2	*15.4*	*0.3*
February	18.2	16.6	17.2	17.9	12.6	16.3	14.8	-1.5	13.8	-2.5	*12.8*	*-3.5*
March	15.8	16.5	14.2	16.4	12.7	14.9	15.9	1.0	14.7	-0.2	*14.7*	*-0.2*
April	15.9	15.7	13.6	14.7	12.2	14.2	14.8	0.5	12.3	-1.9	*18.1*	*3.9*
May	12.1	14.2	13.7	14.5	13.3	13.6	13.3	-0.3	12.9	-0.7	*14.3*	*0.7*
June	14.8	15.6	12.7	14.0	12.6	13.9	13.8	0.0	12.8	-1.1	ND	
Total first half-year	15.5	15.5	14.4	15.1	12.7	14.6	14.4	-0.1	13.5	-1.1	ND	
July	15.5	16.4	15.5	15.6	14.4	15.4	13.2	-2.3	14.0	-1.5	ND	
August	16.6	17.8	15.0	15.7	13.9	15.7	12.0	-3.8	12.6	-3.1	ND	
September	16.0	16.5	12.5	16.0	14.0	14.9	14.2	-0.8	14.5	-0.5	ND	
October	17.0	17.8	20.4	15.1	15.1	17.0	11.6	-5.4	12.7	-4.2	ND	
November	16.5	15.7	16.3	11.5	15.8	15.0	15.5	0.5	15.1	0.1	ND	
December	18.6	17.5	17.2	15.0	15.2	16.6	14.8	-1.8	14.8	-1.9	ND	
Total second half-year	16.6	16.9	16.1	14.8	14.7	15.8	13.5	-2.3	13.9	-1.9	ND	
ANNUAL TOTAL	16.1	16.3	15.3	15.0	13.7	15.2	13.9	-1.3	13.7	-1.5	ND	

Table 34 - Death rates per 100 monthly accidents on the considered network per year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	152.5	155.5	159.6	154.5	152.1	154.7	152.1	-2.7	152.4	-2.4	*158.3*	*3.6*
February	154.4	155.9	158.8	151.9	145.8	153.0	156.1	3.1	143.5	-9.5	*147.3*	*-5.7*
March	153.9	149.2	149.1	150.1	146.9	149.5	153.2	3.7	147.7	-1.9	*146.5*	*-3.0*
April	155.9	150.3	149.4	153.3	147.7	150.9	150.7	-0.2	147.5	-3.4	*125.1*	*-25.9*
May	151.6	155.5	146.6	155.0	148.0	151.2	153.9	2.7	150.5	-0.6	*135.2*	*-16.0*
June	148.9	154.3	147.2	156.5	152.2	151.8	147.6	-4.1	153.5	1.8	ND	
Total first half-year	152.5	153.5	150.9	153.7	148.9	151.8	151.9	0.1	149.3	-2.5	ND	
July	155.1	161.1	157.9	159.9	156.6	158.0	148.2	-9.8	152.7	-5.3	ND	
August	158.0	163.6	152.8	158.1	149.3	156.1	148.1	-8.0	151.9	-4.2	ND	
September	150.4	152.4	151.7	148.4	146.3	149.8	145.8	-4.0	144.4	-5.3	ND	
October	149.7	150.9	154.2	153.2	146.4	150.8	141.1	-9.7	151.9	1.1	ND	
November	144.1	155.5	145.4	151.6	152.3	149.9	146.8	-3.1	149.0	-0.9	ND	
December	150.4	161.5	153.2	154.9	159.0	155.7	151.9	-3.8	159.2	3.5	ND	
Total second half-year	151.7	157.4	152.7	154.4	151.5	153.5	146.9	-6.6	151.4	-2.1	ND	
ANNUAL TOTAL	152.1	155.6	151.9	154.1	150.2	152.7	149.2	-3.5	150.5	-2.2	ND	

Table 35 - Injury rate per 100 monthly accidents on the considered network per year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

Rest of the network

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	2.5	2.4	3.1	2.5	3.4	2.8	2.8	0.0	3.4	0.6	*3.1*	*0.3*
February	2.7	2.5	3.2	3.2	2.6	2.9	3.8	1.0	3.7	0.8	*3.4*	*0.5*
March	2.2	2.8	2.5	2.6	2.8	2.6	2.6	0.0	2.9	0.3	*3.5*	*0.9*
April	2.5	2.5	2.8	2.9	3.1	2.7	3.1	0.3	3.1	0.4	*5.1*	*2.4*
May	2.9	2.6	2.8	3.0	2.9	2.8	2.7	-0.1	2.7	-0.1	*3.3*	*0.5*
June	2.6	2.5	2.8	2.7	2.8	2.7	2.4	-0.3	3.0	0.4	ND	
Total first half-year	2.6	2.6	2.9	2.8	2.9	2.7	2.9	0.1	3.1	0.4	ND	
July	3.0	2.8	3.7	3.5	3.4	3.3	3.6	0.3	3.1	-0.1	ND	
August	3.6	3.4	4.4	3.6	3.7	3.7	3.1	-0.6	4.0	0.3	ND	
September	2.7	2.9	2.4	3.1	2.9	2.8	3.2	0.4	3.2	0.4	ND	
October	2.7	2.9	3.3	2.6	2.8	2.9	2.9	0.0	2.4	-0.5	ND	
November	2.2	2.7	2.9	2.8	2.3	2.6	2.6	0.0	2.7	0.1	ND	
December	2.9	2.8	3.0	3.8	3.5	3.2	3.3	0.1	3.3	0.1	ND	
Total second half-year	2.8	2.9	3.2	3.2	3.1	3.0	3.1	0.1	3.1	0.1	ND	
ANNUAL TOTAL	2.7	2.7	3.0	3.0	3.0	2.9	3.0	0.1	3.1	0.2	ND	

*Table 36 - **Death rates per 100 monthly accidents** on <u>the rest of the network</u> per year - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020*

	BAAC						BAAC				BAAC preliminary data (ONISR estimate)	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average	2020	Deviation from average
January	120.5	120.7	120.7	125.8	120.5	121.7	121.6	-0.1	124.4	2.7	*125.7*	*4.0*
February	121.5	123.0	125.2	121.8	122.7	122.8	122.6	-0.3	123.1	0.3	*120.5*	*-2.3*
March	124.2	124.0	123.1	123.2	123.8	123.7	125.1	1.4	123.3	-0.4	*121.3*	*-2.4*
April	122.2	122.9	123.4	123.3	125.2	123.4	125.4	2.0	124.5	1.1	*121.8*	*-1.7*
May	125.2	125.9	126.2	124.4	123.4	125.0	126.7	1.7	124.4	-0.6	*123.5*	*-1.5*
June	121.2	124.5	123.1	125.8	122.2	123.3	122.8	-0.5	125.8	2.5	ND	
Total first half-year	122.4	123.6	123.6	124.2	123.0	123.3	124.1	0.7	124.3	1.0	ND	
July	126.1	126.2	128.5	128.2	131.1	128.0	130.0	2.1	127.6	-0.4	ND	
August	131.8	130.7	130.9	129.8	129.3	130.5	130.4	-0.2	132.5	1.9	ND	
September	122.5	123.6	123.4	124.6	123.6	123.5	123.5	0.0	124.2	0.7	ND	
October	122.7	123.2	123.7	124.1	120.9	122.9	121.9	-1.0	124.5	1.6	ND	
November	122.0	123.5	120.8	123.5	122.8	122.5	123.6	1.1	124.0	1.4	ND	
December	124.2	123.8	123.7	124.8	124.1	124.1	125.1	1.0	125.3	1.2	ND	
Total second half-year	124.6	124.9	124.9	125.6	125.1	125.0	125.4	0.4	126.1	1.1	ND	
ANNUAL TOTAL	123.6	124.2	124.3	124.9	124.0	124.2	124.8	0.6	125.2	1.0	ND	

*Table 37 - **Casualty rate per 100 monthly accidents** <u>on the rest of the network</u> per year – Source : Official BAAC for 2013-2019 - ONISR estimated data for 2020*

A 4.5 - Considered network: accidents involving a vehicle overtaking on the left

	BAAC – Accidents						BAAC-Accidents			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	373	402	400	407	526	422	450	28.4	460	38.4
Second Half-year	472	400	460	524	560	483	523	39.8	539	55.8
ANNUAL TOTAL	845	802	860	931	1086	905	973	68	999	94

	BAAC – Deaths						BAAC-Deaths			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	74	67	53	81	66	68	73	4.8	57	-11.2
Second Half-year	78	67	71	77	89	76	58	-18.4	63	-13.4
ANNUAL TOTAL	152	134	124	158	155	145	131	-14	120	-25

*Table 38- number of accidents and number of deaths per month in **accidents involving a vehicle overtaking on the left** – Source: Official BAAC*

A 4.6 - Considered network: rear-end collision accidents

Overall data

	BAAC – Accidents						BAAC-Accidents			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	641	751	794	748	1015	790	898	108.2	951	161.2
Second Half-year	786	801	893	995	1044	904	1075	171.2	1003	99.2
ANNUAL TOTAL	1427	1552	1687	1743	2059	1694	1973	279	1954	260

	BAAC – Deaths						BAAC-Deaths			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	44	41	52	45	61	49	45	-3.6	70	21.4
Second Half-year	66	55	59	58	56	59	58	-0.8	58	-0.8
ANNUAL TOTAL	110	96	111	103	117	107	103	-4	128	21

*Table 39 - Monthly number of accidents and deaths in **rear-end and chain collisions** - Source: Official BAAC*

Data on accidents involving at least one heavy goods vehicle

	BAAC – Accidents						BAAC-Accidents			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	75	84	68	92	119	88	98	10.4	95	7.4
Second Half-year	93	98	98	113	103	101	122	21	117	16
ANNUAL TOTAL	168	182	166	205	222	189	220	31	212	23
	0.1177295	0.11726804	0.09839953	0.11761331	0.10781933	11.14%	0.11150532	0.11238368	0.10849539	0.08986175

	BAAC – Deaths						BAAC-Deaths			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	7	6	10	15	12	10	5	-5	9	-1
Second Half-year	20	18	17	16	12	17	13	-3.6	11	-5.6
ANNUAL TOTAL	27	24	27	31	24	27	18	-9	20	-7

*Table 40 - Number of accidents and number of deaths per month in **rear-end and chain collision accidents involving at least one heavy goods vehicle**.– Source : Official BAAC*

	BAAC – Accidents						BAAC-Accidents			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	46	55	42	51	76	54	64	10	56	2
Second Half-year	53	55	67	51	53	56	73	17.2	69	13.2
ANNUAL TOTAL	99	110	109	102	129	110	137	27	125	15

	BAAC – Deaths						BAAC-Deaths			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	4	5	6	7	10	6	1	-5.4	3	-3.4
Second Half-year	8	7	13	5	5	8	7	-0.6	6	-1.6
ANNUAL TOTAL	12	12	19	12	15	14	8	-6	9	-5

*Table 41 - Number of accidents and deaths per month in **rear-end and chain collisions involving at least one HGV striking another vehicle** - Source: Official BAAC*

	BAAC – Accidents						BAAC-Accidents			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	36	37	26	46	57	40	46	5.6	50	9.6
Second Half-year	47	49	40	58	58	50	63	12.6	52	1.6
ANNUAL TOTAL	83	86	66	104	115	91	109	18	102	11

	BAAC – Deaths						BAAC-Deaths			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
Fist half-year	2	1	5	8	3	4	4	0.2	6	2.2
Second Half-year	12	9	7	12	8	10	7	-2.6	5	-4.6
ANNUAL TOTAL	14	10	12	20	11	13	11	-2	11	-2

*Table 42-Number of accidents and deaths per month in **rear-end and chain collisions involving at least one HGV struck by another vehicle** - Source: – Source: Official BAAC*

Appendix 5 - Seasonal adjustment of accidents

The principle of seasonal adjustment was introduced in part 3.2.5 - Seasonal adjustment of accident data to make them comparable).

Seasonal adjustment makes it possible to:

- analyse, describe and explain the chronology of events in the past
- place new data that arise within this perspective
- to derive strategies for the future, or even to make predictions with their reliability threshold (estimation of prediction errors).

The proposed method, well suited to the study of monthly values, is in four steps.

A 5.1 - Calculation of the trend

To calculate the trend, there are several methods. One could simply be to adjust a trend curve by the method of least squares for example, or by fitting a polynomial or other fitted curve.

The major disadvantage here is that such methods do not guarantee freedom from periodic or seasonal trends. However, **a moving-average of order P eliminates seasonal components of the same order**.[32] Therefore, in order to calculate the trend of the variables measuring road accidents, it is proposed to use the **12-month centred moving-average.** As 12 is an even number, special processing is required for end months: half of the value of each of the ends is taken into account.

The value of the monthly trend in the variable $X_{a,m}$ at month *m* of year *a* will thus be given by:

$$ZX_{a,m} = \frac{1}{12}\left(\frac{X_{a,m-6}}{2} + \sum_{i=m-5}^{m+5} X_{a,i} + \frac{X_{a,m+6}}{2}\right)$$

For example, the figure for the July 2015 trend will be taken as the average of the ten months from February 2015 to December 2015 plus half of January 2015 plus half of January 2016.

[32] This comes from the fact that a seasonal component of order P affects the entities k, k+P, k+2P ...etc. In a moving-average of order P, therefore, one and only one of these entities is taken into account, since the “length” of the moving-average is precisely P. Any seasonality of order P is therefore taken into account identically by any moving-average of order P: between them, the moving-averages of order P therefore no longer have seasonality of order P.

A 5.2 - Calculation of seasonal coefficients

For each month *m* of year *a,* it is possible to calculate the difference between $X_{a,m}$ and the trend $ZX_{a,m}$ (moving-average) and then to average these ratios for each month of type m over all the *A* years considered. This average is called the gross seasonal coefficient of month *m* over the period of A years:

$$SX'_m = \frac{\sum_{a=1}^{A} X_{a,m} - ZX_{a,m}}{A}$$

Having by definition assumed that the seasonal component is strictly periodic, each gross seasonal coefficient should therefore be subtracted from the average of all the gross seasonal coefficients, so that the average of the final seasonal coefficients is equal to zero. Thus the seasonal coefficient of month m is:

$$SX_m = SX'_m - \frac{1}{12}\sum_{\mu=1}^{12} SX'_\mu$$

A 5.3 - Calculation of Seasonally Adjusted Data (SAD)

At this stage it is possible to obtain for each monthly data *X* the seasonally adjusted data by subtracting the raw data from the seasonal data:

$$\mathrm{CVS\_X}_{a,m} = X_{a,m} - SX_m$$

Observation of this adjusted variable makes it possible to know, beyond the monthly variations observed, whether the underlying data is specific to the month under consideration. By comparing this data with the trend, which is assigned a confidence interval, it makes it possible to answer the question: is the month in question better or worse than the usual month?

A 5.4 - Application to 2013-2020 raw data

Period January 2019-December 2019

In this case, the seasonal coefficients will be calculated for the period from January 2013 to December 2019 based on the final fatality data. The centred averages will therefore be calculated for all months between July 2013 and June 2019.

The calculation of the monthly seasonal variation coefficients gives the values in table 43.

	Seasonal adjustment coefficients for concerned networks	Seasonal adjustment coefficients for other networks
January	-34.3	-6.9
February	-36.7	-13.5
March	-20.1	-14.4
April	-18.2	-5.5
May	-6.3	-4.7
June	14.8	3.0
July	38.3	16.9
August	17.1	0.9
September	14.1	9.1
October	28.2	11.7
November	-6.7	-6.1
December	9.7	9.6

Table 43: Monthly seasonal coefficients of variation for the number of deaths- calculated on raw fatality data for the period January 2013-December 2019 - Source: Official BAAC for 2013-2019

Using these coefficients, tables of seasonally adjusted fatality values can be compiled.

	BAAC adjusted with seasonal coefficients						BAAC adjusted with seasonal coefficients			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
January	192.3	181.3	192.3	178.3	175.3	183.9	172.3	-11.6	167.3	-16.6
February	175.7	179.7	178.7	203.7	165.7	180.7	157.7	-23.0	178.7	-2.0
March	153.1	178.1	158.1	188.1	184.1	172.3	176.1	3.8	178.1	5.8
April	167.2	176.2	178.2	167.2	191.2	176.0	196.2	20.2	152.2	-23.8
May	128.3	166.3	176.3	190.3	198.3	171.9	176.3	4.4	152.3	-19.6
June	173.2	192.2	171.2	164.2	193.2	178.8	178.2	-0.6	159.2	-19.6
Total first half-year	989.7	1073.7	1054.7	1091.7	1107.7	1063.5	1056.7	-6.8	987.7	-75.8
July	183.7	162.7	182.7	191.7	181.7	180.5	163.7	-16.8	170.7	-9.8
August	194.9	187.9	187.9	179.9	172.9	184.7	141.9	-42.8	157.9	-26.8
September	181.9	181.9	150.9	197.9	173.9	177.3	179.9	2.6	172.9	-4.4
October	164.8	193.8	221.8	181.8	177.8	188.0	126.8	-61.2	136.8	-51.2
November	169.7	177.7	192.7	155.7	188.7	176.9	182.7	5.8	167.7	-9.2
December	193.3	174.3	184.3	190.3	158.3	180.1	167.3	-12.8	151.3	-28.8
Total second half-year	1088.3	1078.3	1120.3	1097.3	1053.3	1087.5	962.3	-125.2	957.3	-130.2
ANNUAL TOTAL	2078.0	2152.0	2175.0	2189.0	2161.0	2151.0	2019.0	-132.0	1945.0	-206.0

Table 44- Number of seasonally adjusted deaths per month on the considered network, by year - Source: Official BAAC

	BAAC adjusted with seasonal coefficients						BAAC adjusted with seasonal coefficients			
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Deviation from average
January	91.9	94.9	110.9	98.9	120.9	103.5	97.9	-5.6	112.9	9.4
February	95.5	95.5	106.5	109.5	88.5	99.1	110.5	11.4	125.5	26.4
March	81.4	117.4	95.4	101.4	117.4	102.6	93.4	-9.2	111.4	8.8
April	92.5	101.5	103.5	99.5	113.5	102.1	111.5	9.4	106.5	4.4
May	106.7	104.7	101.7	114.7	109.7	107.5	102.7	-4.8	101.7	-5.8
June	102.0	101.0	110.0	103.0	113.0	105.8	94.0	-11.8	115.0	9.2
Total first half-year	570.1	615.1	628.1	627.1	663.1	620.7	610.1	-10.6	673.1	52.4
July	105.1	84.1	115.1	109.1	106.1	103.9	109.1	5.2	102.1	-1.8
August	109.1	100.1	126.1	103.1	106.1	108.9	86.1	-22.8	114.1	5.2
September	106.9	111.9	82.9	112.9	99.9	102.9	118.9	16.0	113.9	11.0
October	103.3	113.3	116.3	93.3	101.3	105.5	107.3	1.8	80.3	-25.2
November	95.1	115.1	116.1	115.1	96.1	107.5	98.1	-9.4	102.1	-5.4
December	100.4	92.4	101.4	127.4	114.4	107.2	99.4	-7.8	113.4	6.2
Total second half-year	619.9	616.9	657.9	660.9	623.9	635.9	618.9	-17.0	625.9	-10.0
ANNUAL TOTAL	1190.0	1232.0	1286.0	1288.0	1287.0	1256.6	1229.0	-27.6	1299.0	42.4

Table 45 - Number of seasonally adjusted deaths per month on the rest of the network per year - Source: Official BAAC

Period January 2019-February 2020

If the additional two months of January and February 2020 are to be included, the corresponding provisional data estimated by ONISR must be taken into account. The introduction of new months implies, by construction, recalculating the monthly seasonal variation coefficients.

For this new period, the seasonal coefficients will be calculated for the period January 2013-February 2020. The centred averages will therefore be calculated for all months between July 2013 and August 2019. The fact that the January and February data are provisional will have little impact, especially since previous interim reports from Cerema have shown that the provisional data were to within a maximum of 1 to 2 monthly units of the final data.

Calculation of the 20-month monthly seasonal variation coefficients gives the values in the table 46.

	Seasonal adjustment coefficients for concerned networks	Seasonal adjustment coefficients for other networks
January	-34.3	-6.9
February	-36.8	-13.5
March	-20.1	-14.4
April	-18.2	-5.5
May	-6.3	-4.7
June	14.8	3.0
July	39.3	16.0
August	16.3	1.8
September	14.1	9.1
October	28.2	11.7
November	-6.7	-6.1
December	9.7	9.6

Table 46: Monthly seasonal coefficients of variation for the number of deaths- calculated on raw fatality data for the period January 2013-February 2020 - Source: Official BAAC for 2013-2019 - ONISR estimated data for 2020

Using these coefficients, it is possible to draw up tables of seasonally adjusted fatality figures over the entire period (final and estimated data).

	BAAC adjusted with seasonal coefficients						BAAC adjusted with seasonal coefficeitn				BAAC preliminary data (ONISR estimate) adjusted with seasonal coefficients	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Ecart à la moyenne	2020	Deviation from average
January	192.3	181.3	192.3	178.3	175.3	183.9	172.3	-11.6	167.3	-16.6	190.3	6
February	175.8	179.8	178.8	203.8	165.8	180.8	157.8	-23.0	178.8	-2.0	156.8	-24
March	153.1	178.1	158.1	188.1	184.1	172.3	176.1	3.8	178.1	5.8	111.1	-61
April	167.2	176.2	178.2	167.2	191.2	176.0	196.2	20.2	152.2	-23.8	83.2	-93
May	128.3	166.3	176.3	190.3	198.3	171.9	176.3	4.4	152.3	-19.6	141.3	-31
June	173.2	192.2	171.2	164.2	193.2	178.8	178.2	-0.6	159.2	-19.6	ND	
Total first half-year	989.8	1073.8	1054.8	1091.8	1107.8	1063.6	1056.8	-6.8	987.8	-75.8	ND	
July	182.7	161.7	181.7	190.7	180.7	179.5	162.7	-16.8	169.7	-9.8	ND	
August	195.7	188.7	188.7	180.7	173.7	185.5	142.7	-42.8	158.7	-26.8	ND	
September	181.9	181.9	150.9	197.9	173.9	177.3	179.9	2.6	172.9	-4.4	ND	
October	164.8	193.8	221.8	181.8	177.8	188.0	126.8	-61.2	136.8	-51.2	ND	
November	169.7	177.7	192.7	155.7	188.7	176.9	182.7	5.8	167.7	-9.2	ND	
December	193.3	174.3	184.3	190.3	158.3	180.1	167.3	-12.8	151.3	-28.8	ND	
Total second half-year	1088.2	1078.2	1120.2	1097.2	1053.2	1087.4	962.2	-125.2	957.2	-130.2	ND	
ANNUAL TOTAL	2078.0	2152.0	2175.0	2189.0	2161.0	2151.0	2019.0	-132.0	1945.0	-206.0	ND	

Table 47- Number of seasonally adjusted deaths per month on the considered network, by year - Source: Official BAAC for 2013-2019 – ONISR estimated data for 2020

	BAAC adjusted with seasonal coefficients						BAAC adjusted with seasonal coefficeitn				BAAC preliminary data (ONISR estimate) adjusted with seasonal coefficients	
	2013	2014	2015	2016	2017	Average 2013-2017	2018	Deviation from average	2019	Ecart à la moyenne	2020	Deviation from average
January	91.9	94.9	110.9	98.9	120.9	103.5	97.9	-5.6	112.9	9.4	110.9	7
February	95.5	95.5	106.5	109.5	88.5	99.1	110.5	11.4	125.5	26.4	115.5	16
March	81.4	117.4	95.4	101.4	117.4	102.6	93.4	-9.2	111.4	8.8	77.4	-25
April	92.5	101.5	103.5	99.5	113.5	102.1	111.5	9.4	106.5	4.4	43.5	-59
May	106.7	104.7	101.7	114.7	109.7	107.5	102.7	-4.8	101.7	-5.8	74.7	-33
June	102.0	101.0	110.0	103.0	113.0	105.8	94.0	-11.8	115.0	9.2	ND	
Total first half-year	570.1	615.1	628.1	627.1	663.1	620.7	610.1	-10.6	673.1	52.4	ND	
July	106.0	85.0	116.0	110.0	107.0	104.8	110.0	5.2	103.0	-1.8		
August	108.2	99.2	125.2	102.2	105.2	108.0	85.2	-22.8	113.2	5.2		
September	106.9	111.9	82.9	112.9	99.9	102.9	118.9	16.0	113.9	11.0		
October	103.3	113.3	116.3	93.3	101.3	105.5	107.3	1.8	80.3	-25.2		
November	95.1	115.1	116.1	115.1	96.1	107.5	98.1	-9.4	102.1	-5.4		
December	100.4	92.4	101.4	127.4	114.4	107.2	99.4	-7.8	113.4	6.2		
Total second half-year	619.9	616.9	657.9	660.9	623.9	635.9	618.9	-17.0	625.9	-10.0		
ANNUAL TOTAL	1190.0	1232.0	1286.0	1288.0	1287.0	1256.6	1229.0	-27.6	1299.0	42.4	ND	

Table 48 - Number of seasonally adjusted deaths per month on the rest of the network per year - Source: Official BAAC for 2013-2019 – ONISR estimated data for 2020

Appendix 6 - Confidence intervals of accident data

A 6.1 - Observed and estimated values

The accident variable *X* in month *m*, where *X* can be 'Accidents', 'Killed' or 'Injured' is a random phenomenon. A clear distinction must therefore be made between:

1. Observed values (observed number, observed average, observed trend)
2. The estimated values of the phenomenon that these observations reveal. These statistical values, which characterise the accident phenomenon and its consequences, are a priori unknown. One must try to produce estimates.

Take the image of a bag containing coloured balls, neither the number nor the colour of which is known. It is only after a large number of draws, the balls being returned to the bag after each draw, that it will be possible to estimate the colours contained in the bag (although it is not possible to be completely sure of this) and a law of draw probability formulated a posteriori.

In the same way, it is only knowledge of many values of each variable *X* over many months *m* that will make it possible to approach the probability law of variable *X* and its change over time. This is called the **estimation** of the law of probability that *X* follows.

Consequently, it is not possible to infer the behaviour of variable X **in month** m **by knowing only the raw value of a given month** $Xdef_m$**.** Just as it is not because a “five” comes up three times in a row when a die is rolled that there are more “five” faces than “two” or “six” faces, so too **the raw value of** X **in month** m **cannot be compared as it stands with the value of the previous month or with the value of the same month in a previous year in order to deduce a general trend.**

A 6.2 - Probability laws in accident research

Road traffic accidents and their consequences are random processes with a low probability of occurrence, and these occurrences are considered to be independent of each other.

Moreover, the variables processed are discrete in nature, i.e. they can only take integer values.

The accident phenomenon is similar to a random phenomenon applied to a number *N* of motorists each having a probability *p* of having an accident, or of being killed or injured, and therefore *1-p* of not having one. Taking into account all possible cases among the *N* tests, each variable *X* “Acc, Killed, Severely injured, Slightly injured” could thus obey a conventional binomial law of parameter *N* which could take all values from *0* to *N* with a probability:

$$P(X = k) = C_N^k p^k (1-p)^{N-k}$$

The expectation would be *Np* and the variance *Np(1-p)*.

In practice, however, *N (=all motorists)* is not known. What is estimated, on the other hand, is the number of occurrences of the events over time, which is simply an estimator of *Np*, with *N* large (*=number of vehicles involved*) and *p* small (*=probability of having an accident, being killed or injured*).

It should be remembered that a Poisson Process[33] is a probabilistic model of situations in which a flow of events occurs in succession randomly (in time and space), obeying the following conditions:

1. the probability of occurrence of the event in a small time period or over a small portion of space *t* is proportional to *t*, or *pt*.
2. it is independent of what happened before or elsewhere,
3. the probability of two appearances on the same *t* is negligible.

This law is defined by the probability of k events occurring:

$$P(X=k)=\frac{e^{-\lambda}\lambda^{k}}{k!}$$

This law is characterized by an expectation and a variance both equal to $\lambda=Np$. Its standard deviation is therefore $\sqrt{\lambda}$.

It is easily shown that when N is large, the binomial law converges for any value of k to a Poisson's law.

The random variables linked to road accidents are therefore now considered to be obeying a Poisson process.

The constancy of $\lambda=Np$, a constraint for the approximation, can be interpreted as follows: the mean remaining the same, the greater N is, the lower the probability of occurrence of the phenomenon. In the context of Poisson's law, it is explained by the proportion hypothesis of the probability of the phenomenon occurring in the time under consideration.

A 6.3 - Confidence intervals

A 6.3.1 - Definition

It follows from the above that when the value of an estimator of the probability distribution of the random variable is given, it must be accompanied by a **confidence interval**.

The confidence interval (*CI*) is an interval of values that has a certain probability of containing the true value of the estimated parameter. Less rigorously, it is possible to say that the *CI* represents the range of values within which there is certainty, at a certain fixed probability, of finding the true value. In general, the probability is set at 95%, but it is just as legitimate to impose 99% or accept 90%.

The confidence interval IC_{α} at $\alpha\%$ is notated:

$$IC_{\alpha}=[ICmin_{\alpha};\ ICmax_{\alpha}]$$

and are referred to as the confidence limits associated with α.

[33] from Siméon Denis Poisson (born 21 June 1781 in Pithiviers - died 25 April 1840 in Sceaux), a French mathematician, geometrician and physicist.

A 6.3.2 - Calculation in accident research

The calculation of the confidence interval and the relative precision when reporting an estimated value depends, of course, on the law that the observed variable follows.

However, since the accident rate variables *X* (Acc, Killed, Severely injured, Slightly injured) are Poissonnian, rules valid for normal variables should not be applied to them for calculating confidence intervals, except as an approximation in special cases. This is because it is only for large samples that the limiting central theorem indicates that the mean follows a normal distribution, and that a number of distributions can be approximated by a normal distribution. Let us consider for example the usual formula fixing the confidence interval of the mean of a variable *X* according to:

$$IC_{\alpha} = [\overline{X} - t_{1-\frac{\alpha}{2}} \frac{\sigma^*}{\sqrt{n}}; \overline{X} + t_{1-\frac{\alpha}{2}} \frac{\sigma^*}{\sqrt{n}}]$$

where:

- $\overline{X}$ is the measured average,
- $t_{1-\frac{\alpha}{2}}$ is the value of Student's t-distribution at n-1 degrees of freedom of probability law T_{n-1} such that

$$T_{n-1}(t \leq t_{1-\frac{\alpha}{2}}) = 1 - \frac{\alpha}{2}$$

- σ^* is the variance of the population
- n is the sample size

This formula is valid only if X follows a normal distribution, or when n is large enough to make an approximation (this is the case with large numbers where the central limit theorem applies). **It is therefore not applicable in general for accident research,** and particularly for the present assessment, since the estimate of the annual mathematical expectation is based on the average of five years of data (n=5).

It is shown that the confidence interval of the parameter λ of a random variable according to a Poisson distribution, which is, as we have seen, both its expectation and its variance, at the confidence level *(1 – α)%* is the interval:

$$IC_{1-\alpha} = [\frac{\chi^2_{2S}(\alpha)}{2n}; \frac{\chi^2_{2(S+1)}(1-\alpha)}{2n}]$$

where:

- n is the number of observations and S is their sum,
- $\chi^2_{2S}(\alpha)$ is the quantile of order α of the χ^2 distribution with 2S degrees of freedom, i.e. that $P(X < \chi^2_{2S}) = \alpha / 2$,
- $\chi^2_{2(S+1)}(1-\alpha)$ is the quantile of order 1-α of the χ^2 distribution with *2(S+1)* degrees of freedom, i.e. that $P(X > \chi^2_{2(S+1)}) = \alpha / 2$, X according to a χ^2 distribution with *2(S+1)* degrees of freedom

For large values of *S*, it is shown that it is possible to approximate the χ^2 distribution with *2S* degrees of freedom (*2(S+1)* respectively) by a normal law of expectation *2S* (*2(S+1)* respectively) and of variance *4S* (*4(S+1)* respectively):

$$\chi^2_{2S} \approx N(2S;4S) \text{ and } \chi^2_{2(S+1)} \approx N(2(S+1);4(S+1))$$

A 6.3.3 - Application: Calculation of the confidence interval for averages of raw data over the reference period 2013-2017

Applying this method for the values of S corresponding to the accident rate (Deaths, Accidents, Injuries) observed over the period 2013-2017 (n = 5) leads to the estimation of the confidence intervals for the true Poisson distribution parameter whose observed mean is an estimator (cf. 49).

A statement about the significance of a difference between an annual value and the mean can validly be made only if this value is outside the interval corresponding to the chosen confidence threshold, because the “true” expectation can be anywhere in the confidence interval around the observed mean, which is only an estimator of this.

The difference outside the 99% confidence interval is considered to be highly significant and the difference outside the 95% confidence interval is considered to be significant.

			Confidence interval (CI) of the mathematical expectation at the thresholds of					
			90%		95%		99%	
Networks	**Data**	**Average for 2013-2017**	**CI min**	**CI max**	**CI min**	**CI max**	**CI min**	**CI max**
Concerned networks	Annual deaths	2151	2117.0	2185.4	2110.5	2192.0	2097.9	2205.0
	Fisrt half-year deaths	963	940.3	986.1	936.0	990.6	927.6	999.3
	Second half-year deaths	1188	1162.8	1213.7	1158.0	1218.6	1148.7	1228.3
	Annual accidents	14142	14054.6	14229.8	14038.0	14246.6	14005.4	14279.6
	First half-year accidents	6613	6553.3	6673.1	6541.9	6684.7	6519.7	6707.3
	Second half-year accidents	7529	7465.3	7593.1	7453.1	7605.4	7429.4	7629.5
	Annual injured	19444	19341.5	19546.9	19322.0	19566.6	19283.7	19605.2
	First half-yyear injured	9075	9005.0	9145.4	8991.7	9158.9	8965.6	9185.3
	Second half-year injured	10369	10294.2	10444.2	10279.9	10458.6	10252.1	10486.9
	Deaths for January months	150	141.1	159.3	139.5	161.1	136.3	164.7
	Detahs for February months	144	135.3	153.1	133.7	154.9	130.6	158.4
	Deaths in rear-end and chain collisions	107	99.5	114.9	98.1	116.5	95.5	119.5
	Same with HGV involved	27	23.3	31.1	22.6	32.0	21.4	33.6
Other networks	Annual deaths	1257	1231.0	1283.4	1226.1	1288.5	1216.5	1298.4
	Fisrt half-year deaths	579	561.4	597.0	558.1	600.5	551.7	607.3
	Second half-year deaths	678	659.0	697.5	655.4	701.2	648.4	708.6
	Annual accidents	43406	43252.9	43559.6	43223.6	43589.0	43166.4	43646.6
	First half-year accidents	21077	20970.3	21184.1	20949.9	21204.6	20910.1	21244.8
	Second half-year accidents	22239	22129.4	22349.0	22108.5	22370.1	22067.6	22411.4
	Annual injured	52654	52485.3	52823.1	52453.1	52855.5	52390.0	52918.9
	First half-yyear injured	25419	25301.8	25536.6	25279.4	25559.1	25235.7	25603.2
	Second half-year injured	27234	27112.7	27355.7	27089.5	27379.0	27044.3	27424.7
	Deaths for January months	97	89.9	104.6	88.6	106.0	86.0	108.9
	Detahs for February months	86	79.3	93.1	78.1	94.5	75.7	97.3

Table 49- Intervals of confidence for the 2013-2017 annual averages to represent the true value of the Poisson distribution parameter of accident occurrence

Appendix 7 - Data for travel times

The sample GPS tracks:

Year	Morning rush hour - Working day	Off-peak time Working day	Evening rush hour - Working day	7pm-7am Working day	Saturday 10am - 7pm	Sunday 10am - 7pm	Total
2017	46,436	218,499	53,838	86,357	54,514	52,050	511,694
2019	96,168	404,584	97,051	152,552	98,408	97,344	946,107
Total	**142,604**	**623,083**	**150,889**	**238,909**	**152,922**	**149,394**	**1,457,801**

Table 50: Number of vehicles with historical GPS tracks collected by hourly period and year for calculating travel time

Geographical representation of the 154 routes

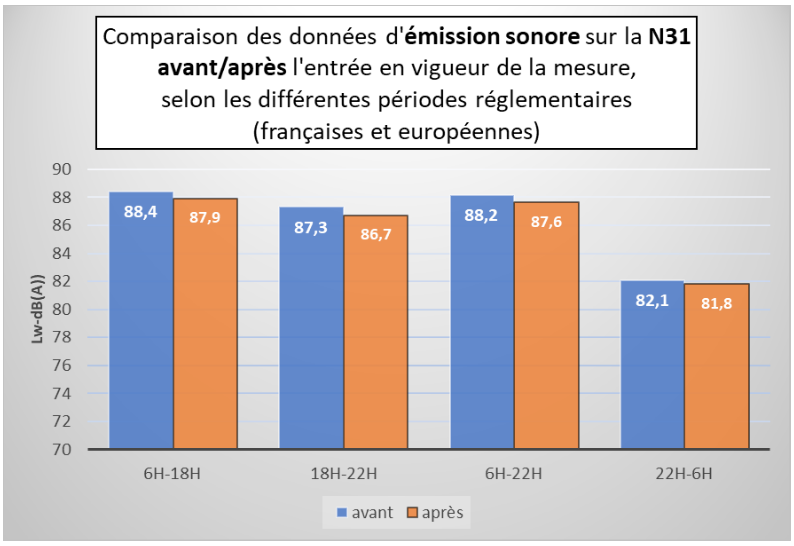
Illustration 41: Geographical representation of the 154 routes analysed for travel times before and after implementation of the VMA80 measure in mainland France (Source: Cerema, 2020, exploitation of FCD data)

Appendix 8 - Data for noise pollution

<u>Results of noise emission modelling before and after the measure came into force on 4 road sections</u>

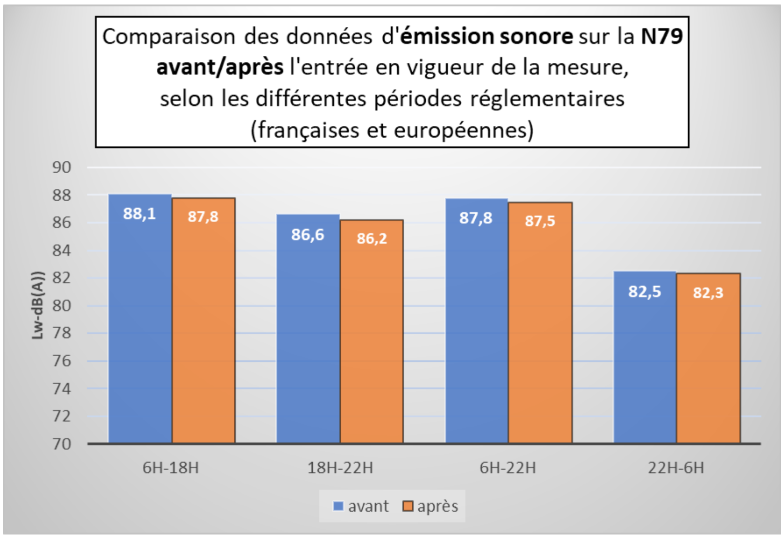
National road 31 (N31) is an interdepartmental road infrastructure linking Rouen in the department of Seine-Maritime to Reims in the department of Marne in its full length. It is part of the Paris great northern bypass.

The section concerned by the assessment is located in the department of Oise between Compiègne and Beauvais and extends over approximately 19 km.



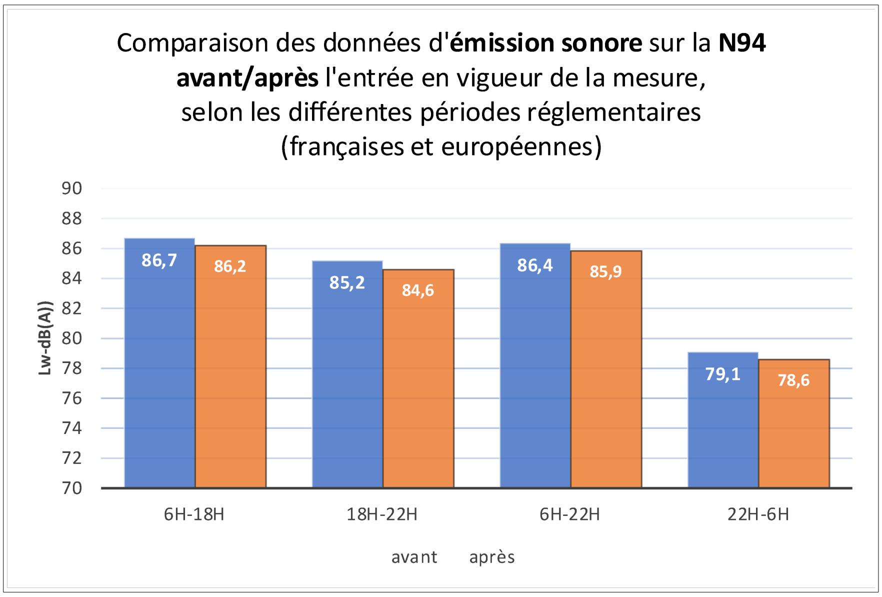
National road 79 (N79) is a section of the Central Europe Atlantic Route (*Route Centre Europe Atlantique* - RCEA). It links Montmarault in the west to Mâcon in the east and provides a link between the A71 and the A6. It is very much used by heavy goods vehicles because it is toll-free and has a dual carriageway layout on many sections. Its strategic position, to the north of the Massif Central, makes it a preferred route for long-distance journeys, particularly for freight transport.

The section studied is located in the department of Saône-et-Loire between Mâcon and Paray-le-Monial.

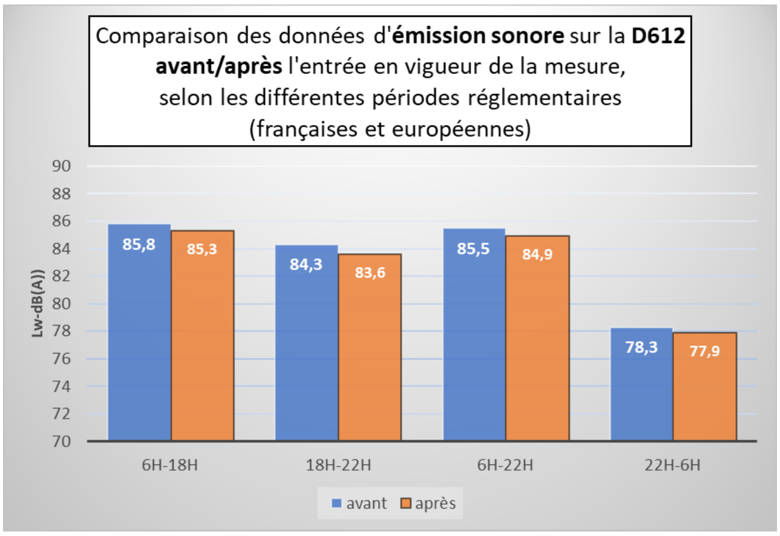


National road 94 (N94) located in the department of Hautes-Alpes, is a 2X1 lane two-way road. It connects Gap, the department capital on the French-Italian border, to the town of Montgenèvre. It is a vital communication route serving the upper Durance.

The section studied in this assessment is located between Embrun and Gap over a length of 26 kilometres.



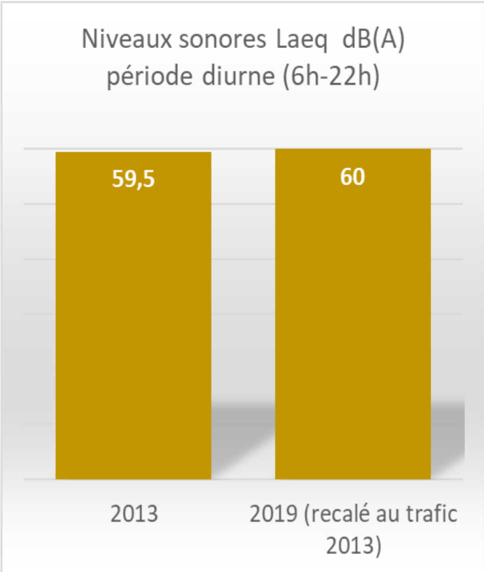
The section selected on the departmental road 612 (D612) is located in the department of Hérault. It is 23 kilometres long, linking Saint Chinian in the west to Béziers in the east. Its current layout, a 2X1 lane two-way road is part of the former national road 112 that linked Albi to Toulouse. Traffic is mainly local; it serves Béziers Ouest, which is home to business parks and industrial zones.



Results of in situ measurements along RN85

The chosen measuring point is located less than 100m from the N85. In accordance with standard NFS 31-085, it can therefore be considered that weather conditions have no impact on the measurement. Nevertheless, for information purposes, meteorological data has been consulted (Météo-France data). They show that there was neither rain nor strong wind (< 3 km/h) during the measurement. This was therefore carried out under good weather conditions, just as in 2013 (same conditions), which guarantees, from this point of view, reproducibility of the measurement.

In order to be able to carry out a before/after comparison of the VMA80 measure, the measurement was adjusted "to acoustically equivalent traffic", thus making it possible to study the effect of speed variation. The adjustment formula, also known as the "long-term traffic estimate" formula prescribed by standard NFS 31-085, takes into account noise levels, traffic and maximum authorised speeds over the two measurement periods (2013/2019).



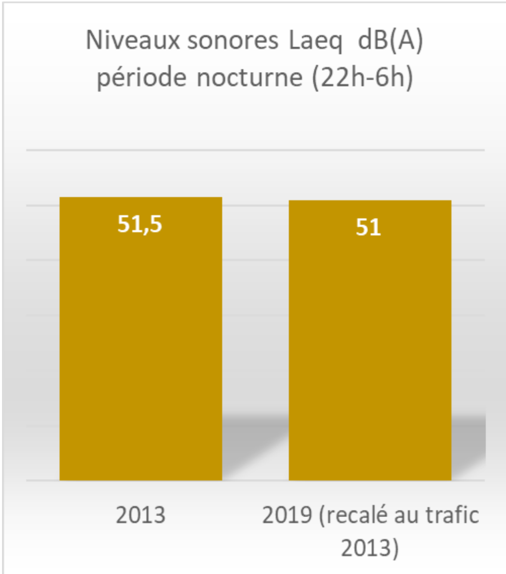


Illustration 42: Comparison of the effect of the VMA80 measure on the measured/readjusted noise levels, on the instrumented site in 2013 and 2019 along the RN85

Appendix 9 - Acceptability / Acceptance survey data

Presentation of the panels studied during the 3 survey waves

	Wave 1 (April 2018)	Wave 2 (March 2019)	Wave 3 (October 2019)
Total number of respondents over 18 years of age	N=5310	N=3797	N=3883
Gender	52.9% of female drivers (N=2809) and 47.1% of male drivers (N=2501)	52.4% of female drivers (N=1992) and 47.6 % of male drivers (N=1808)	52.4% de female drivers (N=2035) and 47.6 % of male drivers (N=1848)
Age	47.1 (average age)	47.2 (average age)	49.3 (average age)
Most frequently used means of transport	LVs are still used by 83.7% of respondents, i.e. 4446 people	LVs are still used by 77.1% of respondents, i.e. 2929 people	LVs are still used by 78.3% of respondents, i.e. 3043 people
Residence	22.5% of them live in a rural area (N=1193)	23.2% of them live in a rural area (883 people),	22.5% of them live in a rural area (873 people),
Income	33.6% of respondents who provided information about their income have an income of more than k€36 (N=1522)	28.7% of respondents who provided information about their income have an income of more than k€36 (1091 people)	29.2% of respondents who provided information about their income have an income of more than k€36 (1135 people)

Table 51: Presentation of respondent panels for the 3 waves of the survey: wave 1 (April 2018), wave 2 (March 2019) and wave 3 (October 2019)

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