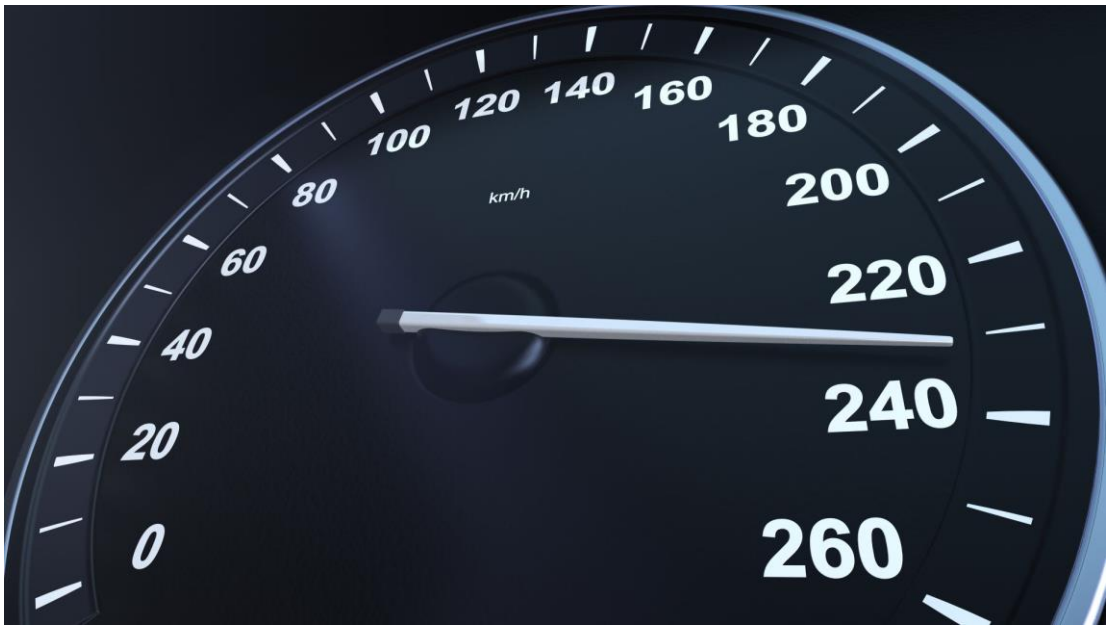
Baseline



Methodological guidelines – KPI Speeding

Version 3.1, April 27, 2021

Baseline

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Any comments or feedback regarding these guidelines, should be sent to baseline@vias.be.

Version history

Version	Date	Changes
1.0	December 18, 2020	First draft version - intended as a framework to discuss methodological issues in the technical committee - draft not yet discussed in the KPI expert group for KPI speed.
2.0	March 18, 2021	Inclusion of comments and reviews from experts and the Technical Committee.
3.0	April 19, 2021	Third version including comments and reviews from Member States.
3.1	April 27, 2021	Minor adjustments

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1 Introduction and aims

The Communication of the European Commission "Europe on the Move – Sustainable Mobility for Europe: safe, connected and clean" of the 13th of May 2018 confirmed the EU's long-term goal of moving close to zero fatalities in road transport by 2050 and added that the same should be achieved for serious injuries. It also proposed new interim targets of reducing the number of road deaths by 50% between 2020 and 2030 as well as reducing the number of serious injuries by 50% in the same period. To measure progress, the most basic – and important – indicators are of course the result indicators on deaths and serious injuries.

In order to gain a much clearer understanding of the different issues that influence overall safety performance, the Commission has elaborated, in cooperation with Member State experts, a first set of key performance indicators (KPIs). The KPIs relate to main road safety challenges to be tackled, namely: (1) infrastructure safety, (2) vehicle safety, (3) safe road use including speeding, alcohol, distraction and the use of protective equipment, and (4) emergency response. The aim of the KPIs is connected to EC target outcomes.

The aim of the BASELINE project, funded partially by the European Commission, is to assist participating Member States' authorities in the collection and harmonized reporting of these KPIs and to contribute to building the capacity of Member States which have not yet collected and calculated the relevant data for the KPIs. The outcomes of this project will be used to set future European targets and goals based on the KPIs.

The purpose of this document is to further describe the minimum methodological requirements needed to qualify for the BASELINE KPIs for speeding, defined as:

Percentage of vehicles travelling within the speed limit

The minimum requirements are described in the Commission Staff Working Document SWD (2019) 283 (see Annex 1: KPI 5 Speeding), further referred to as 'SWD'. In this guideline document the requirements of SWD are quantified and specified for each of the parameters, mainly based on expert consultation and on the following reference:

> SafetyNet: Hakkert, A.S and V. Gitelman (Eds.) (2007) Road Safety Performance Indicators: Manual. Deliverable D3.8 of the EU FP6 project SafetyNet. Retrieved from: http://www.dacota-project.eu/Links/erso/safetynet/fixed/WP3/sn_wp3_d3p8_spi_manual.pdf

Besides specifying the minimum requirements to deliver the main KPI (always marked bold), this document also includes optional supplementary approaches. Member States can decide whether they choose only to follow the minimum requirements or to extend (part of) their methodology, depending on available means and their own research questions.

The target audience of this document are the persons in the Member States participating in the BASELINE EC project that will collect and/or analyse the data to deliver the KPIs.

The minimum requirement is to estimate **the percentage of vehicles travelling within the speed limit**. Besides this indicator, it is highly recommended to also measure the speed below which 85% of drivers are driving (V85), and the average speed (including standard error and standard deviation).

The theoretical population for this KPI refers to the percentage of vehicles travelling within the speed limit over the national territory on sections of roads that allow free flowing traffic. Optionally, when data is available on the total of all trips over the national territory (per vehicle type and road type), the KPI can also be presented as the total number of kilometres driven within the speed limit. For instance, the percentage of vehicles driving within the legal speed limit then reflects the percentage of kilometers driven within the legal speed limit on sections of roads that allow free flowing traffic.

2 Requirements for representative speed measurements

2.1 Free flowing traffic

The minimum requirement for the KPI on speeding is to only look at **free flowing traffic**. This means traffic conditions in which drivers can freely choose the speed they drive and are not restricted by traffic jams, infrastructure (e.g. speed bumps) or road works. To guarantee the observation of free-flowing traffic strict inclusion

criteria are used for the measurement locations (see section 2.3.1). Next to selecting observation locations that allow free flowing traffic, there should also be enough headway between the vehicles of interest included in the analysis and the vehicle driving in front of it. Practically this means only including vehicles that have a headway similar to the distance travelled in 5 seconds at the current legal speed limit. This would for instance be 42, 69, and 167 meters for 30 km/h, 50 km/h, and 120 km/h respectively (Riguelle, 2008). It was found that using this 5 second headway is enough to guarantee free-flowing traffic (Global Road Safety Partnership, 2008).

2.2 Adequate observation equipment

2.2.1 Choice of measurement method

The SWD does not specify a required measurement method. However, the chosen method should allow the observation of **momentaneous speed in free flowing traffic** situations. The focus in these guidelines will be solely on tools that measure the momentaneous (or instantaneous) speed, thus producing spot speed data. Hakkert and Gitelman (2007) describe several methods to collect speed data, which will be explained in more detail in sections 2.2.5 through 2.2.7 of these guidelines.

Speed can also be measured over certain lengths of the road (e.g. with ANPR - Automatic Number Plate Recognition - systems), but this method is outside the scope of these guidelines, since for the KPI on speeding the requirement is to consider free flow traffic only and looking at speeds over certain lengths of road does not allow the analysis of free flow traffic. Similarly, floating car data can only be considered as a data source when it can be guaranteed that free flowing traffic can be analyzed and that the sample of drivers from which the data are obtained is representative of the broader population (e.g. are users of the smartphone application used to obtain the data representative of the Member State population).

2.2.2 Requirements for equipment

As mentioned above, the scope of these guidelines is limited to devices that measure instantaneous speed, or spot speed at a particular location. The SWD does not specify the required equipment to do this. Because the speed measurement will usually be carried out over a short period of time (e.g. a couple of weeks) and ideally at a large number of locations, it is recommended to use equipment which can be installed quickly and flexibly. That is why portable systems such as radars or cameras that can be mounted quickly are preferred. It is possible to use permanent or semi-permanent systems such as loops as well, and therefore these are included in this section for the sake of completeness.

In general, three types of devices for collecting spot speed data can be distinguished (Knodler et al., 2005): out-of-road devices, in-road devices, and hand-held devices (although hand-held devices are not recommended they are included for the sake of completeness). In this section, a basic overview of each of these devices is provided. Note that only the most commonly used devices are described.

2.2.3 Minimum requirements

Regardless of the device used, the equipment used should at least meet the **following minimum requirements**:

- be able to measure, store and deliver the instantaneous speed of individual vehicles;
- be able to measure the number of vehicles (traffic count);
- be able to measure the length of vehicles (in meters to one decimal place). The main reason to include length is that this variable is the most common means to determine vehicle type. When other means are available to determine vehicle type they can be used instead of length;
- be able to record the pass-by time of each vehicle (accurate to the second);
- be able to work uninterruptedly and store data for at least seven days;
- be able to collect data on at least 250,000 vehicles (either by internally storing the data in the device or by sending the data in real-time to an external server);
- be reasonably unobtrusive (not look like speed cameras);
- have a solid, stable installation. Also, the equipment should be calibrated and checked after installation to ensure correct data collection;

- be protected against theft and vandalism (optionally a small disclaimer can be added to the device explaining that the data are not used for law enforcement).

2.2.4 Unobtrusiveness of the equipment

Although this is not required by the SWD, to ensure the measurement of free flow traffic it is highly recommended that the equipment is as unobtrusive as possible. When drivers notice their speed is being measured, it will influence the speed they are driving, rendering the data less meaningful or unreliable. For this reason, hand-held devices are not recommended as it is hard to use these devices inconspicuously. Moreover, using hand-held devices limits the time window for the measurement, as drivers can report the measurement and warn other road users via various websites or smartphone applications.

2.2.5 Out-of-road devices

Doppler-based microwave radars are probably the most recommended method for speed measurements. These radars send a constant wave (24.5 GHz) which rebounds off the surface of the vehicle. From the modified frequency a number of variables can be deduced, typically including vehicle type (based on length), pas-by time, instantaneous speed, and vehicle count. They are placed along the roadway using existing poles such as traffic signs or street lights. Microwave radars are relatively unaffected by weather conditions and are thus often preferred to other types of radars. Another similar technique is frequency modulated carrier wave radar (FMCW): however, the cost of these radars is higher than Doppler radar but the performance is similar.

An advantage of radar systems is that they are relatively non-intrusive and there is usually no need to interrupt traffic to install them, although sometimes a road lane might have to be closed for a short amount of time to install the radar. It must be noted that to ensure the safety of the people installing the radar equipment, this should be done by trained and experienced personnel in accordance with the safety regulations and traffic laws of the Member State. Both radar systems can be flexibly used and installed on a wide variety of locations ranging from city centers to highways provided that poles or lampposts are available to install the radar equipment. This also offers flexibility in selecting locations, allowing a high-quality random locations sample.

A disadvantage is that with these devices, one can only obtain a coarse classification of vehicle types based on their dimensions. Additionally, it is very important that this type of equipment is installed by experienced and trained personnel since poor installation can prejudice the data quality enormously. Also, the devices should be properly calibrated and checked after installation using another type of device (e.g. a speedgun) to ensure the installation is successful. This requirement for experience with the installation should be listed in the proposal if the installation of the equipment is subcontracted.

LIDAR devices (light detection and ranging) work similarly to radars but they use a different wavelength and a different type of wave. LIDARs use a laser wave and gather the reflected wave to obtain information on the detected objects. Their main field of application is enforcement because of their very high accuracy. The cost is significantly higher compared to Doppler-based radars.

Active infrared devices use the same principle as microwave radars but with infrared wavelengths. Smaller wavelengths make them more accurate than microwaves, which is especially helpful in distinguishing between vehicle types. This system too is more expensive compared to Doppler-based radars and is subject to errors in bad weather conditions.

Cameras can also be used when they are placed at a certain height above the roadway to film the passing vehicles. For a correct image setting two points of reference are used with a known distance between them. The device measures the time in which a vehicle drives from the first to the second point. The speed of the vehicle is calculated by means of this time and the known distance. The vehicle length can be deduced as well using this method.

2.2.6 In-road devices

Some roads contain embedded devices that are capable of detecting vehicle speeds. These devices, such as loop detectors, are widely used for traffic surveillance purposes. They generally include a set of wires embedded into the roadway in a rectangular formation. Via the wires an electromagnetic field is created which can detect any vehicle

that passes over the loop. Using these loops, data on traffic volumes can be derived directly. The main advantage is that they are already in place, so data can be collected relatively easily.

An alternative in-road technology is the use of axle detectors. These detectors may be of different types: pneumatic, piezo-electric or quartz-electric. A rough classification of the vehicle can be detected provided that the headways between vehicles are not too small. As these devices do not count vehicles directly but count axles, a correction factor must be applied in order to establish correct traffic information. These correction factors are based on knowledge of the typical traffic characteristics of different road types but they must be adjusted depending on the specificity of the road where measurements are carried out.

2.2.7 Hand-held devices

Radar guns and laser guns are portable instruments that are manually operated. The main advantage is their flexibility since they do not require any installation. The use of radar and laser guns would only be recommended on less-trafficked roads, as it is hard for the observer to monitor vehicle speed on roads with high traffic volumes. An advantage is that they can be used to distinguish particular types of vehicles which are not automatically detected by other systems such as vans, motorcycles, buses, ….

A major disadvantage of using radar or laser guns is their obtrusiveness, thereby possibly influencing the behaviour of the drivers. Another issue is that the overall cost of surveys with radar/laser guns is relatively high due to labour costs of the operators.

2.3 Appropriate observation locations

2.3.1 Choice of locations

Ideally the locations that are selected to obtain speed data should be representative for the whole network of roads in a Member State. Road design characteristics and the surrounding environment influence speeds at which drivers operate their vehicles, so not every location is suitable for free-flow speed measurements. Roads should meet some specific road design criteria in order to be suitable for free flowing traffic speed measurements. These specific requirements are described below.

The SWD specifies **the following minimum requirements for the observation locations**:

- The selection of the locations should be as random as possible with the objective of ensuring a representative sample for the national road network. However, roads where there are known or perceived speed problems are best omitted as these are not representative of the larger road network. The methodology for random sampling is not specified and is for the Member States to decide, but the method used for location selection should be described in the meta-data (sampling will be discussed in more detail in section 2.3.2).
- Measurements should not take place near speed cameras, neither fixed nor mobile.
- A minimum traffic flow of at least 10 vehicles passing per hour is required.

In order to ensure reliability and comparability of speed data, the locations at which speed measurements are carried out must be chosen carefully. All places where vehicles are likely to stop, accelerate or brake should be avoided, since at these locations free flowing traffic cannot be guaranteed. Each location should meet the following criteria as closely as possible:

- straight and uniform section of road (ideally there are no curves nearby that might influence the speed at the point of the measurement)
- section of road where it is possible to drive at a higher speed than the speed limit
- section with a small gradient (<5% on at least 500 meters preceding)
- away from junctions (>500 meters)
- away from any traffic calming device such as speed bumps or narrowing traffic lanes (> 500 meters)
- away from road works (> 500 meters)
- away from pedestrian crossings (> 500 meters)
- away from any speed limit change or sign (> 500 meters)
- away from sections where speed is enforced (e.g. traffic enforcement cameras).

If a location does not meet all the criteria listed above, it is recommended to mention this in the meta-data. It has to be noted that in all likelihood it will be hard to meet all of the above mentioned criteria, especially in built-

up areas. As such, the criteria can be relaxed for locations in built-up areas. Still, it is recommended to select locations that meet these criteria as closely as possible under the circumstances.

2.3.2 Sampling of locations

The SWD does not specify a required sampling method. Member States can define their own sampling methodology. It is important that the locations are representative for the national road network and ideally cover the entire geographical area of the country. Ideally, over time it would be helpful for member states to work together with the European Commission to come up with common bases for sampling. In the meantime, sampling should be based on well-established statistical techniques aimed at achieving a properly representative result.

Selection of locations should be as random as possible, covering the geographical area of the country. There are different options for random location selections: e.g. simple random, stratified random (e.g. random sampling in different regions). The basic process consists of three steps:

(1) First the required number of locations is determined for the entire country or per region.

(2) Next, these locations are randomly selected on a map using the entire area under consideration (e.g. country or region), taking a sufficient geographical spread into account. The specific requirements for each location (e.g. road type or speed limit) do not have to be taken into account at this point. This step is just to ensure a reasonable geographical spread of the randomly selected locations.

(3) Finally, the exact locations that will be used for the observations are manually chosen in the area surrounding the locations randomly selected in step two. At this point, the final selection must be based on the location requirements (different road types), inclusion/exclusion criteria (see section 2.3.1) and practical considerations. This final selection can be done using Google Street View for instance to search for observation locations near the randomly selected locations from step one that meet all the necessary criteria. The selected locations can then also be visited in real life for a final check if needed. Pragmatic considerations related to the observation locations can be taken into account (e.g. safety of observers or people installing measurement equipment should be guaranteed). Care should be taken to ensure that the different road types are also sufficiently geographically spread.

A convenient way of selecting locations randomly (step 2) is to use a GIS system (e.g. cartographic software like ARCView/ARCGIS) as such software can automatically randomly select location points within pre-defined areas. If Member States have no GIS software, step 2 can also be done manually using a national geographic map, e.g. Google maps/Google earth.

The sampled locations should be representative of the entire national territory. When stratification is used, results should be weighted according to traffic volumes by region. It is allowed to re-use the same sampled location for different times of day or days of week. In case such a crossed design is used, this should be indicated in the meta-data. The method used and rationale for choosing the locations of the measurements should be described in the method section of the study.

Ideally, the sampling procedure should comprise a selection from a database consisting of a list of uniform road segments, including their geographic coordinates and their characteristics such as:

- Road type (e.g. motorway, rural road, urban road...)
- Speed limit
- AADT (Annual Average Daily Traffic)
- Number of lanes (not including additional lanes at intersections)
- Length

Additional useful information is:

- Type of median provisions (median divided, flush median, no median)
- Surrounding environment (inner city, outer suburbs, extended shopping area)
- Road design characteristics (slope, curvature, etc.)

The basic characteristics of the locations should be recorded at the start of each observation: GPS coordinates, address or other geographical information, target lane or path and direction which is to be observed, traffic flow

(should be free: no traffic jams, no road works). A code for the sampled location should be included in the database (at least as a qualitative code referring to the location).

In several countries, traffic counters have been placed on major roads with the general purpose of monitoring traffic flows on major roads of the road network. Since these counters can also produce speed data, the speed measurements in several countries are based on these traffic counters. In such cases, speed measurements are not based on a random sampling technique and will not be representative of the road network. For countries that already have permanent counters installed, it may be not feasible to change the system completely. If counters are installed only on main roads, an option would be to randomly sample fewer sites but to sample all of them on "non-main" roads. In this case a specific weighting procedure would be needed when calculating the speed indicators in order to take into account the respective share of main and "non-main" roads.

2.3.3 Minimum sample size

In order to ensure representative results for the entire road network**, the minimum required number of locations is 10 locations for each of the three road types** (urban, rural, motorway; see also section 2.4.1 on road types). The total minimum required number of **observed vehicles is 2000.** However, **for the first stratification level, a minimum of 500 observations per stratum is required** (for the speeding KPI that means 500 observations per road type). Another minimum requirement is that **the proportion of observations at each of the three road types should be a minimum of 20%** (except if a certain road type, like motorways, is non-existent in a Member State).

Defining a minimum required sample size is by definition arbitrary since it depends on the level of accuracy that is considered adequate. With typical overall prevalence percentages in the range of 5 percent, accuracy in the order of range of 1 percent can be considered acceptable.

Accuracy for specific subgroups will by definition be lower. If higher accuracy levels are expected for particular subgroups (e.g. according to region), it is strongly recommended to increase the total sample size.

Since separate samples are taken for each road type and only straight segments of roads that fulfill certain requirements are considered (see section 2.3.1), the variance between locations should be quite small. If large variances are observed on a particular location in the sample, it is recommended to check whether that location fulfils all the requirements to be a good measuring location. If the location does not meet enough requirements, it is recommended to replace that location. If the location does meet enough requirements, it is recommended to increase the number of observations at that location.

Assuming a simple random sampling, the 95% confidence intervals for n=2000 and n=500 are, depending on prevalence (% of drivers within the speed limit) levels:

Prevalence	Lower bound, n=2000	Upper bound, n=2000	Lower bound, n=500	Upper bound, n=500
50%	47,8%	52,2%	45,5%	54,5%
75%	73,0%	76,9%	71,0%	78,7%
90%	88,6%	91,3%	87,0%	92,5%

To summarize, the minimum required sample sizes to provide the speeding KPI are:

- **min. 10 locations per road type = min. 30 locations in total**
- **min. 500 observations per road type**
- **min. 2000 observations in total**
- **the proportion of observations at each of the three road types should be at a minimum 20%**

For more information on random sampling of locations and for determining the minimum sample size, please refer to the SafetyNet general recommendations for SPI (safety performance indicators): http://www.dacota-project.eu/Links/erso/safetynet/fixed/WP3/sn_wp3_d3p8_spi_manual.pdf

2.4 Stratifications and subpopulations

For speed measurements, **the minimum requirements** determined by the SWD should take into account **road type** (at a minimum urban, rural and motorways), **type of vehicle** (only cars are required, other types are optional), **time of day** (day is required, nights are optional), **day of the week** (weekdays are required, weekends are optional), and **the weather** (weather conditions must be good during the observations). In the sections below these minimum requirements will be discussed in more detail.

2.4.1 Road types

The SWD requires that the indicator should at a minimum cover **motorways, rural non-motorway roads (defined as roads outside built-up areas), and urban roads (defined as roads inside built-up areas)**. Ideally the locations that are selected to obtain speed data should be representative of the whole network of roads in a Member State.

In reality, road characteristics will vary between these different road types and therefore speed indicators should be computed separately for these three different road types. For countries where there is more than one speed limit per road type (for instance, rural roads with speed limits of 70 km/h and 90 km/h), it is recommended to compute the indicator either for each speed limit separately or for the most prevalent speed limit (it is not meaningful to aggregate data from roads with different speed limits).

For any given speed limit, it is not a minimum requirement to observe speed at both single and dual lane roads (if both exist). In Belgium, for instance, for most speed limits (50 km/h, 70/km/h and 90 km/h) there are both single and dual lane roads. It is, however, highly recommended to observe single and dual lane roads separately. Aggregating data from single and dual lane roads with the same speed limit is not meaningful and is therefore not recommended. Should a Member State decide to look only at single lane roads or only at dual lane roads, it is recommended to choose the most prevalent type, thereby being more representative of the whole road network.

When communicating about the speeding indicators, some details should be provided about the design of the roads included in the sample (e.g. number of lanes, type of division between opposite lanes, speed limit, …).

2.4.2 Vehicle types

According to the SWD the **minimum requirement for the KPI is to observe the speed of passenger vehicles (cars)**. According to EuroStat, a passenger car is a road motor vehicle, other than a moped or a motorcycle, intended for the carriage of passengers and designed to seat no more than nine persons (including the driver). The term passenger car also covers microcars (small cars which, depending on individual Member State legislation, may need no permit to be driven and/ or benefit from lower vehicle taxation), taxis and other hired passenger cars, provided that they have fewer than 10 seats in total. This category may also include vans designed and used primarily for transport of passengers, as well as ambulances and motor homes. Excluded are light goods road vehicles, as well as motor coaches and buses and mini-buses/mini-coaches (https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Passenger_car). This definition of a passenger car is similar to the UNECE definition of M1 vehicles: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9 seats total.

Optionally, motorcycles, vans, small trucks (between 6.00 meters – 12.00 meters) and trucks/ heavy goods vehicles (> 12 meters) can also be measured. When more vehicle types are considered, using the UNECE vehicle classification scheme is recommended.

Results should clearly define vehicle types included in the observations and should be presented separately for different vehicle types. Small vans might be hard to distinguish from person cars, and therefore a certain percentage of the sample might contain small vans as well. This is hard to avoid and is acceptable, since in any event small vans are not that different from person cars in size and driving characteristics.

The way to distinguish between vehicle types depends on the measuring technique. With radar/laser guns, a human observer is present, allowing a more accurate categorization of vehicles. (It is recommended that an observer receives training to ensure that the classification is as accurate as possible). Most widespread automatic speed monitoring techniques (loops, tubes, radar classifiers) require that the classification of vehicles is obtained by indirect measurements:

- Roadside radars determine the lengths of vehicles on the basis of the time they stay in the beam of radar.

- Pneumatic tubes give information on vehicle lengths, number of axles and sometimes axle loads (based on the pressure on the strips).
- Inductive loops use algorithms based on the expected vehicle distribution, the computed speeds and the occupancy rate of the loops to classify the vehicles. The determination of vehicle types becomes coarse when the traffic flow is heavy, usually resulting in an overestimation of the proportion of long vehicles.

Fortunately, even the coarser classifications (by inductive loops or roadside radars) are satisfactory to distinguish light vehicles (such as passenger cars) from other vehicles, at least when the traffic flow is not too heavy.

A specific problem with heavy vehicles is that these often have different speed limits compared with cars or light duty vehicles. Furthermore, different types of vehicles are similar in length (buses, coaches, trucks) and may also have different speed limits. Devices that determine the vehicle type on the basis of vehicle length may thus classify vehicles with different speed limits within the same category. Based on the national situation, computation of indicators for 'long vehicles' on the basis of this kind of equipment may thus be less meaningful.

2.4.3 Time period (time of day, day of the week, month)

The SWD requires at a minimum Member States to carry out speed measurements **during daylight hours on weekdays**. Measurements at night and in the weekends are optional but highly recommended. Comparisons between day and night are especially recommended due to the difference in traffic conditions and in the composition of the population of drivers between the two periods. The results should be shown separately for day and night and weekdays and weekend days.

Ideally, measurements should be carried out in a month that is "neutral" as far as seasonal variation in traffic is concerned. This means avoiding both school and bank holiday periods (especially summer, as it has the longest holiday period) and the winter period (due to a risk of bad weather). It is thus recommended to carry out the measurements during late Spring or early Autumn.

The number of periods of measurement and the length of time during which it is possible to measure might vary depending on the measuring technique that is used and on the available resources (e.g. handheld devices operated by people versus roadside radars that can measure 24/7). The exact time periods covered by the measurements should be indicated in the meta-data.

2.4.4 Region

The SWD states that the indicator should be representative of the whole Member State territory. To obtain speed indicators at regional level, a stratified random sample of locations according to region (e.g. NUTS1 regions) can be considered. If there are exceptions (e.g. for islands), they should be precisely defined and communicated.

If Member States want to obtain meaningful speed indicators at regional level it is highly recommended to apply all the minimum requirements defined for the national level to the regional level. So, for instance, one should cover the three minimum required road types per region as well as the minimum required sample size (e.g. the 2000 observations and 10 locations per road type required at national level would then be recommended for the regional level).

When stratification by region is used, results should be weighted according to traffic volumes by region in order to compute the KPI at national level (see also section 2.5.1 on Post stratification weights and statistical analysis).

2.4.5 Weather

Measurements should not be carried out in bad weather conditions (e.g. heavy rain, snow, ice, strong winds or fog). Member States are free to define the exclusion criteria and report them together with the data. The main reasons for wanting to avoid bad weather conditions such as heavy rain are that these conditions can affect both speed and radar measurements. It is recommended to consult the people installing the radar equipment on what amount of rain will have a negative impact on the data quality.

2.5 Data analysis

2.5.1 Post stratification weights and statistical analysis

The KPI (percentage of vehicles driving within the speed limit) must be provided separately by road type, vehicle type (if more vehicle types are included beyond passenger cars), and time period (if more time periods are included beyond daytime on weekdays).

For each level of stratification, results should be weighted according to traffic volumes (or mileage data per vehicle type if available) by level of stratification. It is recommended to use the exact values for each combination of stratification levels considered (e.g. traffic volume for highways on weekend nights for personal cars in a certain region).

As indicated above, traffic volumes can either be inferred from existing national mobility (survey) data or estimated by using traffic counts during the measurement sessions or period. When counting during the measurement sessions or periods it is highly recommended to use an automatic counter. Most automated equipment such as radar can also collect traffic count data. Counting should be done at the same location and direction as the measurements and separately for different vehicle categories and time periods (day, night, week, weekend). Optionally, counting can be carried out by human observers. In that case, the counting of all relevant vehicle categories should last at least 10 minutes at each location during each time period included in the speed measurement.

2.5.2 Expected results, data delivery and methodological report

The **minimum required speeding indicator is the percentage of vehicles driving within the speed limit** (at national level).

In addition to this indicator, it is highly recommended to also report the following speed indicators:

- average speed (including the standard deviation and standard error)
- V85 (the speed below which 85% of drivers are driving, i.e. the 85th percentile of speed)

Results should also include the number of locations and the unweighted number of drivers the results are based on.

National speeding indicators should be reported separately according to the following minimum required parameters:

- Vehicle type (personal cars)
- Road type (motorways*****, rural roads*****, urban roads*****)
- Time period (daytime on weekdays)

***** It is recommended to also provide results separately for different speed limits. Aggregating data from roads with different speed limits is not meaningful.

Optionally, data from non-free flow traffic can be analyzed and reported besides the required speeding indicators for free flow traffic.

Together with the above estimates, a report should be submitted that describes the methodology of the field work and the statistical techniques used to weight and analyze the results. Member States are free to determine the statistical analysis techniques and tools.

In addition to this, all Member States are expected to provide **metadata** on the applied regulations and procedures related to this KPI (e.g. legislation on speeding).

For the **data delivery** to the Baseline consortium (inclusion in the Baseline database), three possible levels of aggregation are possible (further instructions on dataset structure and variables will be provided later):

1) **Minimum level requirement: point estimates for all the minimum required observation categories (speeding indicator for cars on 3 road types during daylight hours on weekdays)**.
2) Medium level: crossed-level matrix of all considered levels of disaggregation (crossed point estimates) + confidence intervals.
3) Ideal level: also, delivery of the raw cleaned data (not pure raw data). Data cleaning is the process of preparing data for analysis by removing or modifying data that is incorrect, incomplete (only if the minimally

required data is missing), irrelevant, duplicated, or improperly formatted. This data is usually not necessary or helpful when it comes to analyzing data because it may hinder the process or provide inaccurate results.

3 Summary of minimum requirements

	Minimum requirement	Optional
KPI	• Percentage of drivers within speed limit • Free-flow traffic	• Average speed (+ Standard Deviation and Standard Error/Confidence Interval) • V85 • Non free flow traffic data
Location	• Random selection • Representative of entire national road network • Measurements should not take place near speed cameras, either fixed or mobile • A minimum traffic flow of at least 10 vehicles passing per hour is required	• Stratification by Regions
Road type	• Motorways • Rural roads (defined as roads outside built-up areas, but no motorways) • Urban roads (defined as roads inside built-up areas)	• Differentiate between single and dual lane roads for rural and urban roads • Differentiate between speed limits within rural and urban roads
Vehicle type	• Passenger cars	• Motorcycles • Vans and light trucks • Heavy trucks • Buses
Time period	• Weekdays • Daylight hours • Spring/autumn	• Weekend • Night-time hours
Weather	• Good conditions	
Sample size	• Min 2000 observations • Min 500 observations / road type • Min 10 locations / road type • The proportion of observations at each of the three road types should be at a minimum 20%	

References

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Annexes

Annex 1: KPI 5. Key Performance Indicator for speeding

Ref: COMMISSION STAFF WORKING DOCUMENT - EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero, SWD (2019) 238, https://ec.europa.eu/transport/sites/transport/files/legislation/swd20190283-roadsafety-vision-zero.pdf

Rationale: Speeding is very regularly cited as one of the most common collision causation factors and is related to both collision occurrence and severity.

Definition: **Percentage of vehicles travelling within the speed limit.**

Methodological aspects

Aspect	Minimum methodological requirements
Road type coverage	The indicator should cover motorways, rural non-motorway roads, and urban roads. The results should be presented separately for the three different road types.
Vehicle type	The indicator should include at least passenger vehicles (cars). Buses and goods vehicles (light [less than 3.5t] and heavy [more than 3.5t]) and powered two-wheelers are optional in a first phase (results should be presented separately for each vehicle type if possible).
Location	Member States to decide on the locations of the measurements, but measurements should not take place near safety cameras whether fixed or mobile. The choice of locations should be based on random sampling if this is possible, and in any case made with the objective of ensuring a representative sample.
Time of day	All Member States should elaborate the indicator for day hours in free-flow traffic: the night indicator should be optional due to its higher cost. The results should be shown separately for day and night.
Day of the week	Measurements to be carried out on Tuesdays, Wednesdays or Thursdays. Weekend measurements also possible but optional, and again should be shown separately if carried out.
Month	Measurements to be carried out preferably in late spring and/or early autumn.
Weather	Measurements should not be taken in bad weather conditions (e.g. heavy rain, snow, ice, strong winds or fog). Member States will define the exclusion criteria and report them together with the data.
Tolerance	No tolerance (beyond the error margin of the measuring device), i.e. the values recorded should be those measured by the instrument.

Annex 2: Rationale behind the minimum sample requirements

The methodological guidelines for all KPIs are designed to ensure international comparability between KPI values while taking into account feasibility and affordability. To that end the methodological guidelines have been defined in such a way that accurate and representative results can be obtained for all parameters of interest at a reasonable cost.

Obviously, the larger the sample of observations and locations for observation, the more accurate the KPI estimates for the different strata will be (e.g. a KPI value for a particular type of road, or a particular part of the week). Increasing the number of observations and locations however implies increasing field work costs. Statistically, the required minimum sample size depends mainly on the desired accuracy of the final estimates, for which no absolute value can be determined *a priori*. Therefore, for the main KPI estimates a pragmatic evaluation was made of the expected confidence intervals at different sample sizes and population parameters. Giving priority to feasibility and affordability, as a rule of thumb the minimum total number of observations was set at 2,000, the minimum number of observations for different strata at 500. It was agreed that this should allow to identify statistically meaningful differences between countries at an affordable price. For some countries, this will imply disproportionate sampling of certain strata compared to the distribution of traffic volumes over different strata. This is however required to allow statistically meaningful international comparisons at the level of each of the strata at interest.

The same pragmatic logic was followed for determining the minimum number of 10 locations for observation for each of the required road types of interest. Once again, there is no statistical rationale for determining the required minimum number of locations to ensure representativeness of the observations for the entire country. This mainly depends on the amount of variance between locations and within a country. Giving priority to affordability, a rule of thumb was also used to define the minimum number of locations at 10 per stratum. In order to ensure representativeness for the entire country larger numbers of locations might be required for larger countries. Taking field work costs into account, it was however decided to only identify the minimum requirements and leave decisions on the final number of locations to the discretion of the member states. Equally importantly, in order to ensure representativeness of the measurement locations these should be randomly selected as far as possible.

The main objective in defining the minimum methodological requirements is to keep a balance between affordability of the field work and the requirements to make meaningful international and historical comparisons. Therefore, the emphasis is placed on the minimum requirements that can also be taken into account by smaller countries. It is however of interest to any member state to increase the accuracy of the KPI estimates by boosting the number of locations and the number of observations.