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# Comparing speed measurement methods for evaluating interventions

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## Abstract

**Background:** Speed management is a cornerstone of the Safe System approach to road traffic safety, underpinning nearly all related interventions. Lowering traffic speeds enhances the ability to react in time to avoid collisions and significantly reduces the force of impact when crashes occur, thereby mitigating the severity of injuries. Even modest reductions in average driving speeds can yield substantial safety benefits. For example, a 10% decrease in mean speed is estimated to result in a 20% reduction in injury crashes and a 40% reduction in fatal crashes (OECD/ITF, 2018; based on Elvik, 2013).
Effective speed management is therefore central to the development of a Safe System. Beyond preventing deaths and serious injuries, it also contributes to broader societal goals such as creating sustainable communities, enhancing urban liveability, and promoting public health, safety, and equity.
Among the nine recommendations developed by an academic expert group (Swedish Transport Administration, 2020), excessive speed is identified as a major issue in most countries—posing a significant challenge for governments worldwide. In Sweden, it is estimated that full compliance with speed limits could reduce the number of road fatalities by approximately 20% (Vadeby, 2023).
To improve speed compliance and lower average speeds, increased enforcement is a commonly used strategy. Many countries have now introduced automated speed enforcement systems. These camera-based systems typically operate in two forms: spot speed cameras, which monitor and enforce speed at a specific location, and section control, which automatically enforces compliance based on the average speed over a defined road segment. Earlier studies have investigated the effects of spot cameras as well as section control and found that both spot speed cameras and section control are effective in reducing mean speeds, P85 and speed variations between vehicles, Soole et al. (2013) and Vadeby and Howard (2024).
To evaluate the effects of different interventions aiming to control speed, different types of speed measurement methods are often used. It is crucial to have measurements that give a correct picture of the actual speeds at the location or area where the intervention is performed but it is also important to consider other aspects such as cost effectiveness and road worker safety when performing the measurements. Examples of different measurement methods commonly used are pneumatic tubes, radar and probe data.
An ongoing study contains two different tasks, the first is to evaluate the effects of speed cameras used in portals in Sweden and the second is to analyse and explore different types of evaluation methods at the locations where speed cameras will be applied in 2026.
The aim of this study is to explore three different measurement methods often used to evaluate speed management interventions such as speed cameras. The different methods studied are pneumatic tubes, radar and probe data from INRIX.

**Method:** Speed measurements are carried out at three different locations in Sweden. The measurements took place in the south of Sweden during one week in May 2025. Two of the locations are situated near intersections at 2+1 roads[2] and one location at a dual carriageway road. Speed limit, annual average daily traffic (AADT) and type of measurement equipment at each location are specified below:

**Location 1:** Speed limit 70 km/h, AADT 11 000 veh/day. Pneumatic tubes, radar and INRIX.
**Location 2:** Speed limit 70 km/h, AADT 12 000 veh/day. Pneumatic tubes and INRIX
**Location 3:** Speed limit 70 km/h, AADT 32 000 veh/day. INRIX.

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[2] *A wide road with 2 lanes in one direction and one lane in the other. The different directions are separated by a median barrier and the number of lanes in each direction are alternating.*

The speed measurements are conducted on straight road stretches with a visibility distance above 300 meters. Speed data collected by pneumatic tubes stretched across the road measures speed at the location of the tubes. The data contain information on the speed of individual vehicles as well as the vehicle type but do not include separate measurements for each lane.
Radar speed data was collected by a radar system placed on a portal above the road and like the tubes, spot speed is measured at a specific location. These data contain the speed of individual vehicles and can also separate the speeds in different lanes. However, since the measurement equipment is placed above the road, it is difficult to obtain a good classification of vehicle type.
INRIX data provides anonymized traffic data sourced from a wide range of inputs including GPS signals from vehicles and mobile devices, road sensors, and telematics systems. This data is commonly used to analyse traffic patterns, vehicle movements, and travel behaviour across road networks. Data is collected for a pre-defined road segment and data on minute-level is provided. The road segments studied are between 620 m and 1150 m in length. INRIX data do not contain data of individual vehicles, and the penetration rate and vehicle type are not known. The study is not designed so that an exact comparison can be made, but rather to investigate whether similar conclusions can be drawn from the different measurements.
To compare the different measurement methods, data will be analysed at an hourly, daily, and weekly level. Statistical inference based on ANOVA (see Montgomery, 1991) will be carried out to investigate differences concerning measurement equipment and time resolution. The space-mean-speed will be calculated for all measurement method types. In addition, the speed compliance, speed variation and speed distribution will be calculated for the tube and radar measurements which collect the speed of individual vehicles.

**Results:** When comparing pneumatic tubes and radar, preliminary results show that looking at four days (96 hours), radar seems to observe between 3–10 % more vehicles than the pneumatic tubes. Looking at the space mean speeds, the pneumatic tubes estimate the speeds to be about 1 km/h higher than measured by radar and consequently the measured speed compliance is 3–6 %-units higher when measured by radar. In the intersections the space mean speeds are between 71 and 72.5 km/h. The shape of the speed distribution is similar when comparing speed data from tubes and radar.

For INRIX data, the road segments are between 600 and 1150 m and their locations are pre-defined and not possible to change to fit the aim of this study. For location 1 and 2, the INRIX road segments are cut at the intersection and for respective direction there are two consecutive road segments covering the intersection and that in stage 2 of the study might be influenced when speed cameras are installed. For both locations, the road segments have about 10–15 % with speed limit of 70 km/h and 85–90 % with speed limit of 100 km/h. The space mean speeds for the INRIX road segments are between 82 and 88 km/h, reflecting the large part of 100 km/h speed limit. For location 3, the INRIX road segments cover the location of the planned speed camera portal and have speed limit 70 km/h across the whole road segment. Space mean speeds are estimated to be 70 km/h in one direction and 74 km/h in the other direction, which is a reasonable result compared to the other speed measurements at 70 km/h. The study is ongoing, and more results will be available and presented at the time of the conference.

**Discussion and conclusion:**

Speed management is a fundamental component of the Safe System approach, aiming to reduce road traffic injuries and fatalities. To support effective speed management, reliable speed measurement is essential. This study investigates three commonly used methods: pneumatic tubes, radar, and probe data (INRIX).

Each method showed distinct advantages and limitations in this study. Pneumatic tubes provide detailed data on individual vehicle speeds and types but cannot differentiate lanes. Radar systems, mounted above the road, offer lane-specific data but struggle with vehicle classification. INRIX data, derived from GPS and telematics, covers longer segments and offers minute-level resolution but lacks individual vehicle data and known penetration rates. One limitation is that the road segments are pre-defined and it need to be investigated how well the covers the location of interest.

Preliminary results show that radar detects slightly more vehicles than pneumatic tubes and reports lower space mean speeds, leading to lower estimated speed compliance. The shape of the speed distribution is similar between radar and tubes, suggesting consistency in traffic behaviour. INRIX data reflects higher speeds due to the inclusion of road segments with higher speed limits, especially at locations 1 and 2.

The study highlights the importance of selecting appropriate measurement methods based on the evaluation context. While spot measurements (tubes and radar) are useful for detailed analysis, segment-based data (INRIX) provides broader traffic insights. Understanding these differences is crucial for accurately assessing

the impact of speed interventions like camera enforcement. As the study progresses, further analysis will help determine the most effective and practical approaches for speed evaluation in support of road safety goals.

**Keywords**: Speed management; pneumatic tubes; radar; Inrix data; evaluation.

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