Impact of Road Checks on Compliance with Safe Following Distances Between Vehicles on Motorways in Austria

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Abstract

This article deals with the issue of the impact of visible road checks, i.e. simulated radar speed measurement, on compliance with safe following distances on motorways in Austria. It contains a theoretical analysis of the characteristics of a safe following distance, explains the issue of safe following distances in relation to Austrian legislation and subsequently presents an experiment to ascertain the impact of road checks on compliance with safe following distances on a three-lane motorway in Austria and its results. Based on the results of the experiment, it was found that simulated radar road checks on motorways influence the behaviour of drivers, in particular by encouraging a slight speed decrease, but also a substantial increase in the distance between vehicles and therefore a substantial increase in traffic safety.

Keywords: Safe distance; driver's behaviour; roadside check

Introduction

One of the possible causes of traffic accidents is the failure to observe a safe following distance between vehicles, i.e. a traffic accident occurs when the driver of a vehicle following another vehicle is unable to slow down or stop in order to avoid a collision when the vehicle in front suddenly slows down or stops, because he or she fails to keep a sufficient distance. In many countries this safe distance is not specifically defined, but in good weather conditions drivers are recommended to observe a two-second rule in the case of passenger vehicles and a three-second rule in the case of heavy goods vehicles over 3.5 *t*. Relevant Austrian legislation, however, defines the safe following distance and drivers who fail to observe it may be fined by the Austrian police. The distance for which a fine may be imposed is defined as 0 - 0.2 *s*, or a less severely punishable range of 0.2 – 0.4 *s*. In neighbouring Germany, for example, this distance is defined in units of length, i.e. in

metres. The purpose of legal definition of "an unsafe following distance" is to increase the authority of the police and in particular to increase traffic safety.

The aim of this paper is to present the results of research whose goal was to hypothesise as to whether visible road checks on motorways in Austria have any impact on compliance with safe following distances.

Characteristics of Safe Following Distances between Vehicles

A safe following distance behind a vehicle marked "*b*" is influenced by a number of factors. In the event that two vehicles are following one another on a road and the vehicle in front suddenly slows down or stops, the safe following distance of the following vehicle is substantially affected by the speed of both vehicles, the deceleration of the individual vehicles and the reaction time of the driver of the following vehicle, which necessarily includes the time of visual perception, mental reaction, decision-making and muscular reaction of the driver and the technical response time of the braking system following the driver's command and the response time of the braking system until full braking effect is achieved.

The formula for calculating a safe following distance between vehicles with different deceleration and speed is as follows:

$$b \geq v_2 \cdot t_{r2} + \frac{v_2^2}{2 \cdot a_2} - \frac{v_1^2}{2 \cdot a_1}$$

where the following units are used:

b……. safe distance between two vehicles [m],
v_1……....speed of the first vehicle [m/s],
v_2…….. speed of the second vehicle [m/s],
t_{r2}…….…….. reaction time of the second driver [s],
a_1…….…….. deceleration of the first vehicle [m/s^2],
a_2…….…….. deceleration of the second vehicle [m/s^2].

If both vehicles are travelling at the same speed and are able to achieve the same deceleration in the specific traffic conditions, it is possible to simplify the formula so that the minimum safe following distance is given by the reaction time of the driver of the second vehicle.

$$b \geq t_{r2}$$

Safe Following Distances in Austrian Legislation

Safe following distances are defined in Austrian legislation in Section 18 of the Straßenverkehrsordnung (StVO - Road Traffic Regulations) Act, and respective sanctions for failure to observe these distances in Sections 7, 26 (2a) and 30 of the Führerscheingesetz (FSG - Driving Licence) Act. The

above-mentioned legislation defines, among other things, the necessity to maintain an adequate safe distance at any speed and, at the same time, to ensure that the distance is sufficient for the driver of the following vehicle to stop his/her vehicle at any time, even in the case that the driver of the vehicle in front suddenly starts to brake.

Failure to observe the regulations regarding safe following distances is divided according to the severity of the breach as follows:

- If the distance between the two vehicles is shorter, in particular between 0.2 and 0.4 *s*, the driver placed on record and may have to pay a fine of up to €726.
- If the distance is shorter than 0.2 *s*, the driver has to pay a fine of between €36 and €2180 and shall have his/her driving licence revoked for at least 6 months.

Furthermore, the above-mentioned Straßenverkehrsordnung Act defines the obligation of drivers of long vehicles (i.e. lorries, articulated lorries and buses) to observe a minimum distance of 50 *m* on roads outside municipalities.

Measurement Method

Measuring was carried out on the A1 three-lane motorway in Austria near municipality of Viehdorf in the direction of St. Pölten, on 13 October 2016 from 4:00 pm. At the time the measurements were carried out, the weather conditions were favourable, visibility was good, the maximum temperature was around 10 ˚*C* and the wind was light, reaching about 2 *m/s*. The section selected for measurement contains two consecutive flyover junctions (approx. 480 *m* apart) made up of two bridges.

Figure 1 **Layout of measurement locations**

For the purposes of the experiment, the traffic situation on the first bridge was measured with the measuring device hidden so as not to influence drivers, while on the second bridge, a simulated radar device was placed in a location visible to drivers. The data acquired in this manner was analysed and evaluated.

Figure 2 Situation in the second location with a simulated road check – radar speed measurement

Findings

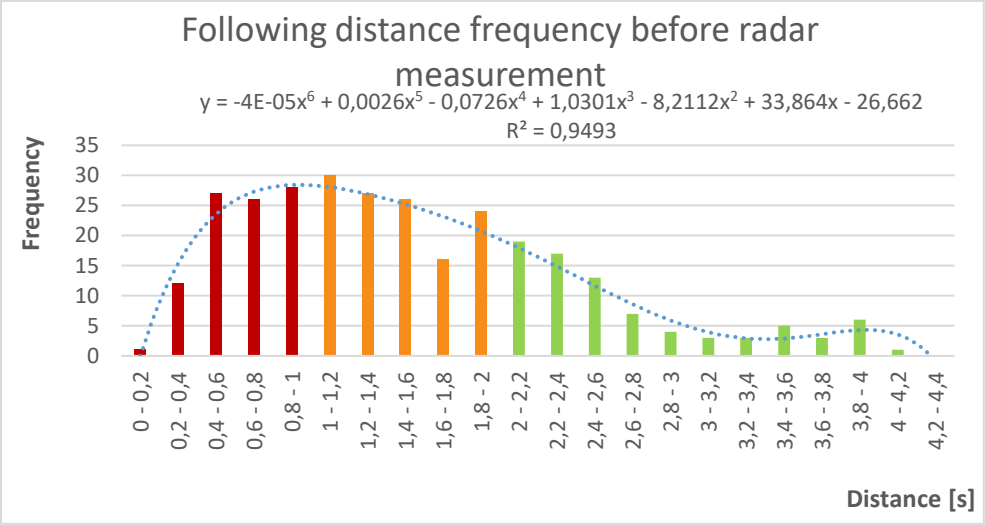
At the time of measurement, traffic intensity in the measured section in the direction of St. Pölten was 2544 *vehicles/h*. This data was used for the analysis of a basic set of 530 vehicles in the given section. Sample sets were selected from the basic set within the individual measurement sections containing at least two vehicles following each other in the same lane in the given section with a maximum distance of 100 *m*. In the case of the first section, the sample set contained 298 vehicles and in the second measurement section the sample set contained 241 vehicles. Variables included the average speed of vehicles in the given section and average distance between vehicles. These values constitute a data file.

It follows from the results of the analysis of the sample set of vehicles shown in the following table that the average speed of vehicles was 123 *km/h* and the average following distance was 1.5 *s*. On average, the shortest following distance was maintained by passenger vehicle drivers and van drivers in the left lane, specifically 1.1 *s*, followed by passenger vehicle drivers in the middle lane, specifically 1.4 *s*.

Lane	Vehicle category	Average speed [km/h]	Average distance [s]	Number of vehicles
Left	passenger cars	137	1.1	92
	vans	131	1.1	15
Middle	passenger cars	129	1.4	111
	vans	122	1.9	16
	lorries	87	1.6	5
Right	passenger cars	106	2.0	6
	vans	97	2.4	14
	lorries	86	2.4	39
Total	-	123	1.5	298

Table 1 Measured values in the sample set in the first section

The following graph shows a histogram of the distance between vehicles in the first measured section, from which it is apparent that in the sample set of vehicles, approx. 32 % of drivers maintained a distance lower than 1 *s*, i.e. not even within the distance corresponding to a standard driver's reaction time, approx. 41 % of drivers maintained a distance of 1 to 2 *s*, and approx. 27 % of drivers maintained a distance exceeding 2 *s*. Therefore, approx. 73 % of drivers failed to maintain the recommended two-second rule in the sample set from the first section. The abovementioned relevant Austrian legal regulations regarding a minimum following distance greater than 0.4 *s* was violated by 13 drivers in all, i.e. approx. 4 % of the drivers in the sample set.



Graph 1 Following distance frequency before radar measurement

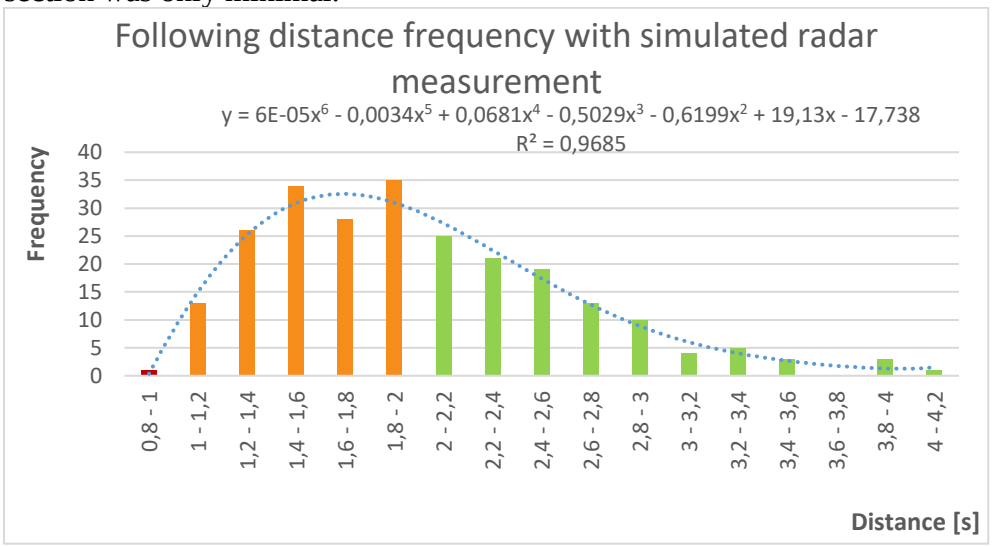
It follows from the results of the analysis of the sample set of vehicles shown in the following table, that the average speed of vehicles was 119 *km/h*, i.e. 4 *km/h* slower in comparison with the first section, while the average following distance was 2.0 *s*, i.e. 0.5 *s* longer. On average, the shortest following distance was maintained by lorry drivers in the left lane, specifically 1.4 *s*, followed by passenger car drivers and van vehicle drivers in the same lane, specifically 1.7 *s*.

Lane	Vehicle category	Average speed [km/h]	Average distance [s]	Number of vehicles
Left	passenger cars	130	1.7	79
	vans	128	1.7	11
	lorries	81	1.4	2
Middle	passenger cars	125	1.9	89
	vans	116	2.4	17

	lorries	88	2.1	8
Right	passenger cars	114	2.0	3
	vans	95	2.3	8
	lorries	84	2.9	24
Total	-	119	2.0	241

Table 2 Measured values in the sample set in the second section

The following graph shows a histogram of the distance between vehicles in the second measured section with simulated radar measurement, where it is apparent that in the sample set of vehicles, only one driver, i.e. approx. 0.4 % of all drivers, maintained a distance lower than 1 *s*, therefore failing to observe the distance corresponding to a standard driver's reaction time, approx. 56 % of drivers maintained a distance between 1 and 2 *s* and approx. 43 % of drivers maintained a distance exceeding 2 *s*. Therefore, approx. 56 % of drivers failed to maintain the recommended two-second rule in the sample set from the first section. The above-mentioned relevant Austrian legislation regarding a minimum following distance greater than 0.4 *s* was not violated by any of the drivers in the sample set. The graph shows the positive impact of the simulated visible radar speed check on following distances, even though it is apparent that the speed decrease in the given section was only minimal.



Graph 2 Following distance frequency with simulated radar measurement

In the second study, a sample set was selected from the basic set of vehicles containing vehicles with a following distance shorter than 100 *m*, where the pairs of vehicles were the same in both the first measured section and the second section with simulated radar speed measurement. This sample

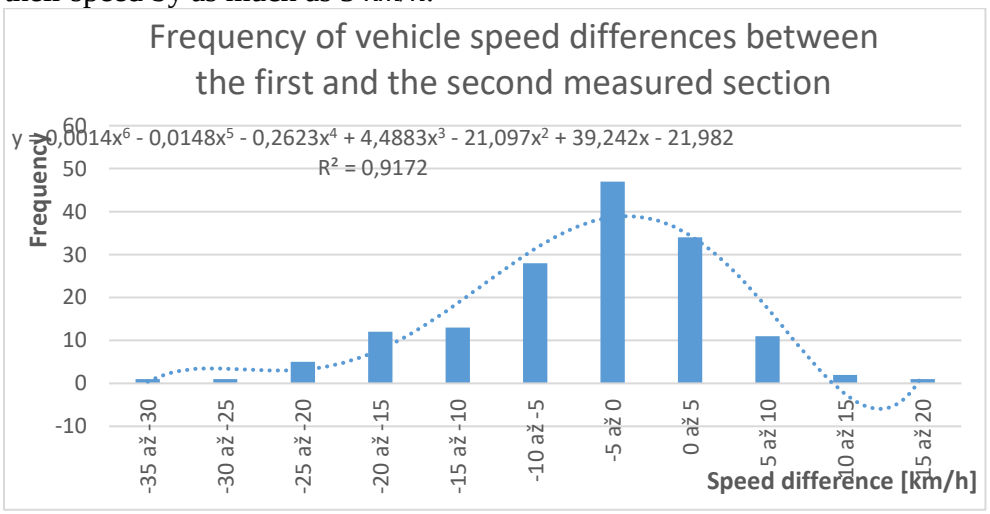
set comprised a total of 155 vehicles and, in keeping with the input conditions of the sample set, did not include possible traffic situations where, for example, a third vehicle driving in a faster lane moves in between two vehicles in a way which disproportionately shortens the distance between these two vehicles.

It is apparent from the table that the vehicles in the sample set in the second study slowed down between the first and second measured sections by 4 *km/h* on average and conversely increased their following distance by 0.9 *s* on average. The table shows that the drivers of passenger cars in the left lane decreased their speed the most, specifically by 7 *km/h*, while the following distance was most adjusted by van drivers in the left lane and lorry drivers in the right lane, specifically by 1.0 *s*.

Lane	Vehicle category	Average of speed difference [km/h]	Average of distance difference [s]	Number of vehicles
Left	passenger cars	-7	0.9	56
	vans	1	1.0	11
Middle	passenger cars	-5	0.8	56
	vans	-5	0.9	4
	lorries	0	0.7	1
Right	passenger cars	5	0.4	3
	vans	-4	0.6	3
	lorries	0	1.0	21
Total	-	-4	0.9	155

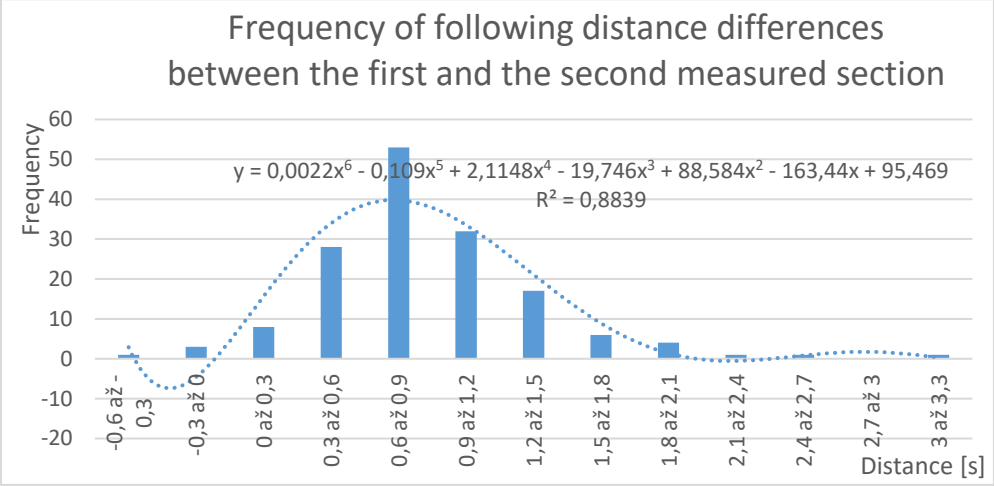
Table 3 Different values between the two measured sections for the second sample set

The following graph shows a histogram of the speed difference between vehicles in the first and the second measured sections, where it is apparent that in the sample set of vehicles, approx. 30 % of drivers decreased their speed by as much as 5 *km/h*.



Graph 3 Frequency of vehicle speed differences between the first and the second measured section

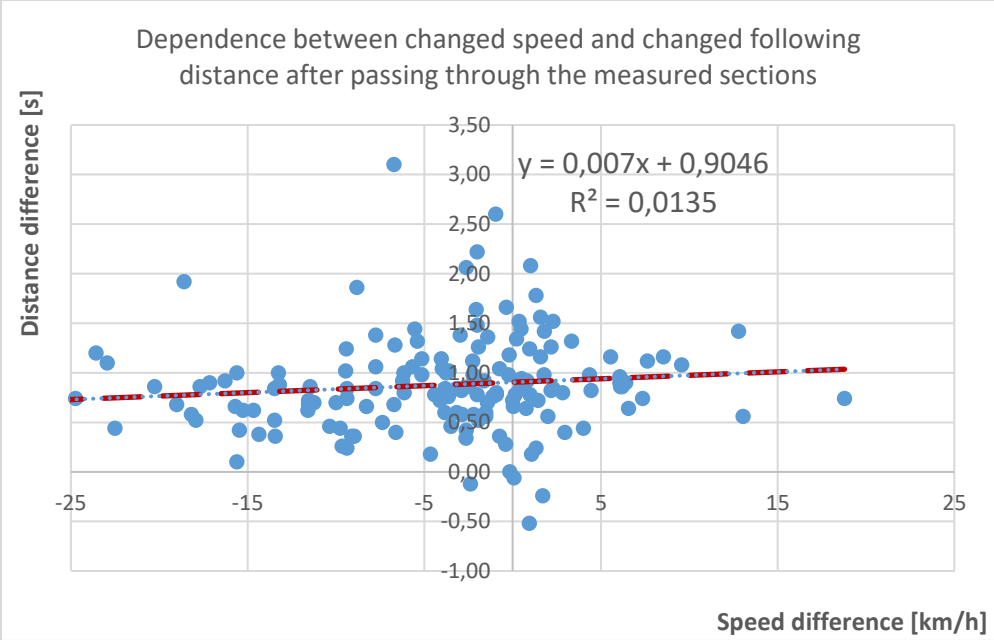
The following graph shows a histogram of the difference in the following distances of vehicles between the first and the second measured sections, whereas it is apparent that in the sample set of vehicles approx. 34 % of drivers increased their following distance by 0.6 to 0.9 *s*.



Graph 4 Frequency of following distance differences between the first and the second measured section

The correlation coefficient between the speed of a vehicle and its distance behind another vehicle for the sample set of 155 vehicles in the case of the first and the second measured sections is approx. 0.39 or 0.35, thus from a statistical viewpoint, there is a partial indirect linear dependence between the speed and the following distance in the first and the second measured sections.

The correlation coefficient between a change of speed and following distance after travelling through the measured section is equal to approx. 0.11, which indicates a slight direct linear dependence between the change in speed and change in following distance, i.e. if a driver changes speed after passing a “Keep a Safe Distance” traffic sign, then the distance to the next vehicle also changes to a certain degree.



Graph 5 Dependence between changed speed and changed following distance after passing through the measured sections

Conclusion

According to statistics, the highest risk factor in the traffic system with a substantial impact on traffic accident rates is the human factor or the participation of people in traffic. Although the average number of deaths due to traffic accidents in Austria has been decreasing in the past few years, it is necessary to further contribute to this trend with effective measures for enhancing road traffic safety.

Failure to comply with safe following distances is one of the causes of traffic accidents. The number of such traffic accidents may be reduced by developing driver-assistance systems, but also, among other things, by improving drivers' behaviour by way of education, better adjusted sanctions, an increased number of road checks, etc.

Based on the results of the first and second study in this report, it is apparent that road checks on motorways influence the behaviour of drivers, in particular by encouraging a slight speed decrease, but also a substantial increase in the distance between vehicles and therefore a substantial increase in traffic safety.

References:

Adell, E., Várhelyi, A., & Fontana, M. D. (2011). The effects of a driver assistance system for safe speed and safe distance – A real-life field study.

Transportation Research Part C: Emerging Technologies, 19(1), 145-155. doi:10.1016/j.trc.2010.04.006

Bertolazzi, E., Biral, F., Da Lio, M., Saroldi, A., & Tango, F. (1009). Supporting Drivers in Keeping Safe Speed and Safe Distance: The SASPENCE Subproject Within the European Framework Programme 6 Integrating Project PReVENT [Online]. *Intelligent Transportation Systems, Ieee Transactions On*, 11(3), 525-538. https://doi.org/10.1109/TITS.2009.2035925

Bradáč, A. (1997). *Soudní inženýrství* (1st ed., Vol. 1). Brno, Czech Republic: CERM.

Burg, H., & Moser, A. (2007). *Handbuch Verkehrsunfallrekonstruktion: Unfallaufnahme - Fahrdynamik - Simulation*. Wiesbaden: Vieweg.

Ge, T., Fu, X., Ma, J., & Kang, L. (2014). Study on the Improvement of the Safety Distance Model Based on Speed Difference [Online]. *Applied Mechanics And Materials, 641-642*, 923-928. https://doi.org/10.4028/www.scientific.net/AMM.641-642.923

Germany. (n.d.). *Führerscheingesetz*. Retrieved April 15, 2017, from https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10012723.

Germany. (n.d.). *Straßenverkehrsordnung*. Retrieved April 15, 2017, from https://www.ris.bka.gv.at/Dokument.wxe?ResultFunctionToken=08ed89bb-79b2-4105-a78e-ca92c33d4455&Abfrage=Bundesnormen&Kundmachungsorgan=&Index=&Titel=StVO&Gesetzesnummer=&VonArtikel=&BisArtikel=&VonParagraf=18&BisParagraf=&VonAnlage=&BisAnlage=&Typ=&Kundmachungsnummer=&Unterzeichnungsdatum=&FassungVom=30.04.2017&VonInkrafttretedatum=&BisInkrafttretedatum=&VonAusserkrafttretedatum=&BisAusserkrafttretedatum=&NormabschnittnummerKombination=Und&ImRisSeit=Undefined&ResultPageSize=100&Suchworte=&Dokumentnummer=NOR12155399.

OECD data: Road accidents [Online Database]. (n.d.). Retrieved April 15, 2017, from https://data.oecd.org/transport/road-accidents.htm#indicator-chart

Park, K. S., Lee, A. J., & Koh, B. K. (2001). Drivers Characteristics in the Perception of a Lead Vehicles Deceleration Level. *International Journal of Cognitive Ergonomics*, 5(2), 125-136. doi:10.1207/s15327566ijce0502_3

Summala, H. (2000). Brake Reaction Times and Driver Behavior Analysis [Online]. *Transportation Human Factors*, 2(3), 217-226. https://doi.org/10.1207/STHF0203_2

Summala, H., Lamble, D., & Laakso, M. (9807). Driving experience and perception of the lead car's braking when looking at in-car targets [Online]. *Accident; Analysis And Prevention, 30*(4), 401.

Wada, T., Doi, S., Imai, K., Tsuru, N., Isaji, K., & Kaneko, H. (2007). On drivers braking behavior in car following. *SICE Annual Conference 2007*. doi:10.1109/sice.2007.4421389

Wei, Y., & Chen, Y. (2010). Safe Distance Based Location Privacy in Vehicular Networks. *2010 IEEE 71st Vehicular Technology Conference*. doi:10.1109/vetecs.2010.5494209

Yang, D., Zhu, L. -ling, Yu, D., Yang, F., & Pu, Y. (1402). An enhanced safe distance car-following model [Online]. *Journal Of Shanghai Jiaotong University (Science), 19*(1), 115-122. https://doi.org/10.1007/s12204-014-1479-5