## Summary of the Diploma Thesis

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**Title: Quantifying the Safety Level of Intergreen Interval Considering the Random Character of the Decisive Parameters**

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One of the leading requirements of the road-traffic is the warranty of safety. This is decisive especially for the intersections of roads with equal altitudes because in that case the roadways are partially shared from different traffic streams. In order to arrange this partial sharing on the intersections traffic signals are installed. The installation of traffic signals provides above all the increase of traffic safety and improvement of traffic quality. This is an operational process which, due to rotational stopping or giving right of way to conflicting traffic streams, influences the traffic sequence. Such encounters exist normally within the stage changes. In order to avoid such encounters on signalized intersections, the so-called intergreen interval is set as a part of signal program. The intergreen interval in the signal programs in Germany includes the yellow-time, yellow-and-red-time and all-red-time.

The intergreen interval is calculated in Germany according to the Guidelines for Traffic Signals, abbreviated as RiLSA (“Richtlinien für Lichtsignalanlagen”). RiLSA defines the intergreen interval as the time duration between the end of the green for one traffic stream and the onset of green for a conflicting traffic stream. Theoretically traffic safety should increase as well, if the intergreen interval increases. However, because of the human factor and the need to maximize the capacity of an intersection, the intergreen interval and its influence on safety is constricted. Thus, the extension of intergreen intervals does not always lead to safety improvements and safety problems would occur not only within short intergreen intervals but also within long ones. It should be noted that it is impossible to achieve absolute safety in practice.

The parameters, which are used for the calculation of intergreen intervals in Germany, are considered as constant, according to RiLSA. This means, RiLSA neglects the random nature of these parameters. Alternative approaches for the calculation of intergreen intervals in other countries don't take this stochastic nature in account either. As a result, it can be assumed that these constant parameters can cover just a part of the real traffic behavior. Furthermore, this deterministic approach doesn't let the calculation of intergreen interval refer to a defined level of safety. In other words, the calculation model of RiLSA doesn't provide the quantification of realized level of safety.

This study aims to find out a model following RiLSA 2010, in which the random nature of the parameters of intergreen interval calculation should be considered. Moreover, this model should allow the quantitative determination of the level of safety. For this purpose the model that Jakob has developed in 1980 is used as the basis for the own model.

Although his assumption is in theory appropriate, the major problem of Jakob's model is that he doesn't consider a time gap between the conflicting traffic streams. In other words, at signalized intersections an entering vehicle can theoretically occupy the so-called conflict area as soon as the last clearing vehicle leaves this area (no headway). However, because of the fact that, for each type of traffic flow, headways between vehicles have to be intended, his assumption doesn't correspond to the practice. Furthermore, according to the own assumption, his conclusion which states that no correlation exists between entering time and clearing time, does partially correspond to reality.

Hence, it might be helpful to clear some questions: What should be the minimum value of this headway so that a sequence can be considered as safe or unsafe? How do the drivers react in such situations which can be interpreted as hazardous? If a minimum value for this headway occurs, isn't it an indication for the relationship between the sequences mentioned above? This study will attempt to answer these questions with the help of the in literature so-called PET (Post Encroachment Time) which can be interpreted as the necessary time gap to ensure safety.

One of the major aims of the own model was to fill in the mentioned gap of Jakobs model. Furthermore, by means of surveys, was attempted to determine to which extent the assumption of Jakob is warrantable. The surveys were carried out in Darmstadt close to east railway station at the intersection Landgraf-Georg-Straße and Fiedlerweg. The selected variables are the entering time $T_E$ and the clearing time $T_A$ which were defined by Jakob. With the aid of measurements can be stated that an "explicit" up to "tight" interrelation between the variables exist.

In addition, by means of the own model and the measured values, was attempted to find out the level of existing danger. This was carried out at first for the current intergreen interval. Afterwards, it was tried to find out the quantitative impact of the intergreen interval on the level of safety. Thereby the hazard probability and the achieved or rather potential safety level were determined consecutively. On the one hand the sequences with PET values of less than a defined PET-Level ($PET_{min}$) and as a result with an occurrence of a concrete approach, will be indicated as hazardous situations. On the other hand, the sequences in which the duration of entering time exceeds a predefined threshold or reach a predefined percental deviation from $T_{E,\ min.}$ will be recorded as hazardous situations, too. It should be noted that in this case the actual value of PET should be above the threshold for PET.

Beyond that, it was tried to find out how the selected intergreen interval influences the level of safety. For this it would be better to vary the current intergreen interval of the intersection but because of the fact that it was not actually practicable, this is theoretically realized. In this case it is assumed that the variation of the intergreen interval takes place with the variation of the so-called all-red time, as a result of which the cycle length correspondingly was either reduced or extended. Furthermore, it was assumed that through the reduction or the extension of the actual intergreen interval the entering and clearing vehicles would move towards or away from each other. As a result, the threshold referred above would be displaced.

With respect to the measured values that correspond to the actual intergreen interval, it was estimated that the probability of safety is 95% and the probability of dangerous situations consequently 5%. That means that five percent of the entire sequences cannot be covered with a selected intergreen interval based on RiLSA. Additionally, in this study, the probability of dangerous situations and the probability of safety are calculated theoretically for the remaining intergreen intervals of 4 to 8 seconds. Hence, it can be assumed that the variation of the intergreen interval doesn't influence the achieved level of safety respectively.

It should be noted that there are some crucial points, which cause doubt about the model and the surveys. Therefore, the determined values of the level of safety can be seen as inaccurate but at the same time it can be taken for granted that at least the determined trend of safety matches the reality so that these can be seen as an approximation to the actual values.

Finally, by means of the own model could be illustrated that through the extension of the intergreen interval above decisive values the level of safety won't be influenced remarkable. Thus, from certain values on, no longer is the achieved level of safety crucial for the decision about the useful intergreen time but the achievable capacity.

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