

# Vehicular Transmission Reliability over Blind Intersections

Mouhamed Abdulla and Henk Wymeersch

Vehicle-to-vehicle (V2V) communication can improve road safety and traffic efficiency, particularly around critical areas such as intersections. We analytically derive V2V success probability near an urban intersection, based on empirically supported line-of-sight (LOS), weak-line-of-sight (WLOS), and non-line-of-sight (NLOS) channel models. The analysis can serve as a preliminary design tool for performance assessment over different system parameters and target performance requirements. The most interesting outcome of this research is the ability to design the network and explicitly quantify the tolerated number of simultaneous transmissions that could occur at the same time-frame of the wanted transmission, while still meeting the pre-determined target reliability. Meanwhile, we will also discuss means to determine the fraction of vehicular traffic realizations that achieve the target reliability. This is a more granular finely detailed analysis, and it will basically builds on the results presented earlier.

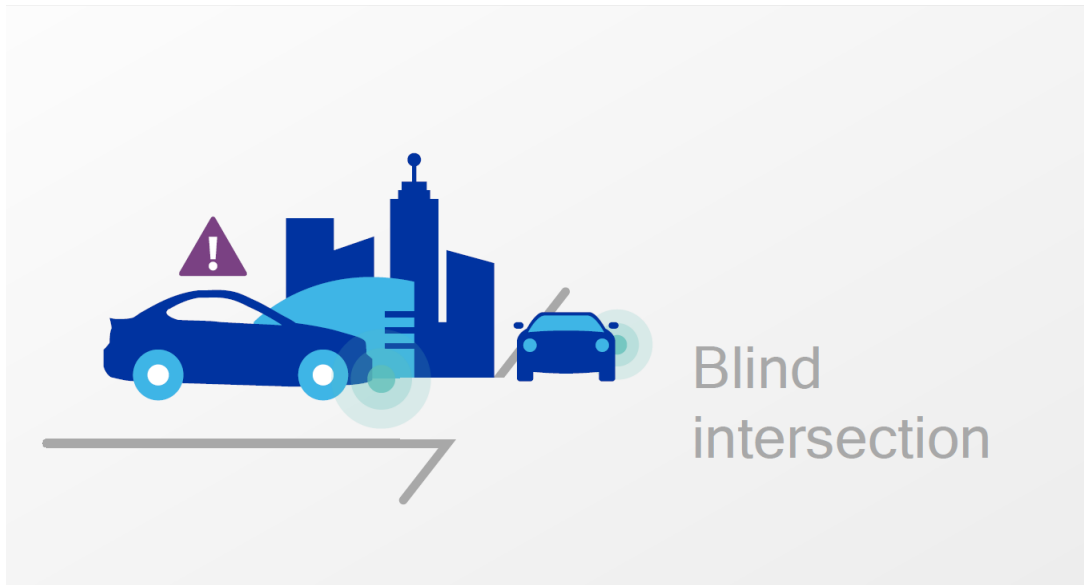


Fig. 1. Blind intersections are estimated to cause  $\sim 47\%$  of all accidents. V2x can overcome this challenge, since packet reliability can lead to road-safety.

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European Commission on Project

## Motivation

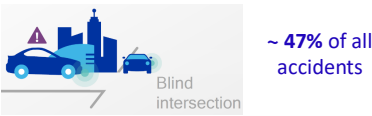
### 5G Use-Cases



### V2x Communications



### Intersections/Corners

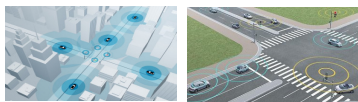


### Target Reliability



## Research Questions

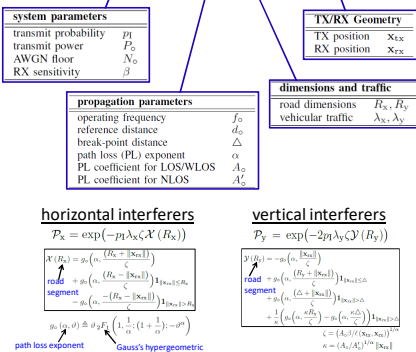
- How to **quantify/evaluate** V2V packet reliability in blind intersections?
- How to **design vehicle ad hoc network (VANET)** to meet a fail-safe target reliability?
- How to go beyond **misleading averages** and explicitly study **reliability of each vehicular traffic realization**?



our research attempts to **uncover the collection of these important unknowns!**

## Quantifying Reliability

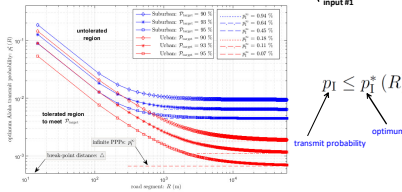
$$\mathcal{P}_c(\beta, \mathbf{x}_{TX}, \mathbf{x}_{RX}) = \mathcal{P}_{\text{noint}} \mathcal{P}_X \mathcal{P}_Y$$



## Network Design

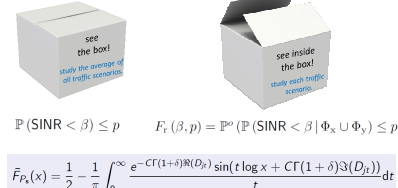
- road dimension:**  $R \geq \Delta$  (channel breakpoint distance)
- target reliability:**  $\mathcal{P}_{\text{target}} < \mathcal{P}_{\text{noint}}$  (success probability with no interference)
- requirements:**  $\mathcal{P}_{\text{noint}} \mathcal{P}_X \mathcal{P}_Y \geq \mathcal{P}_{\text{target}}$  (success probability, worst-case scenario)
- design guidelines:** (input #1, input #2)

$$p_1^*(R) = \frac{-\beta N_0 / (P_0 \ell(\mathbf{x}_{TX}, \mathbf{x}_{RX})) - \ln(\mathcal{P}_{\text{target}})}{\zeta \lambda(\mathcal{X}(R) + 2\mathcal{Y}(R))}$$

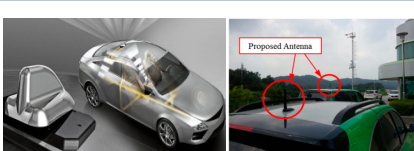


## Meta Distribution

- basic analysis (averages)** (see the box!)
- advanced granular analysis (Palm Calculus)** (see inside the box!)

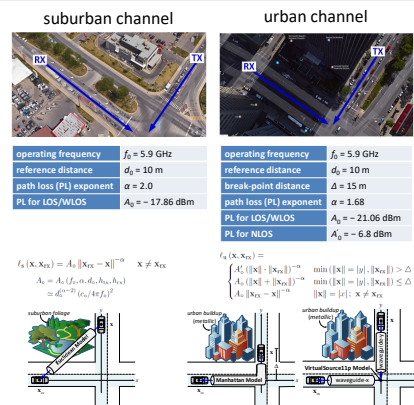


## System Parameters

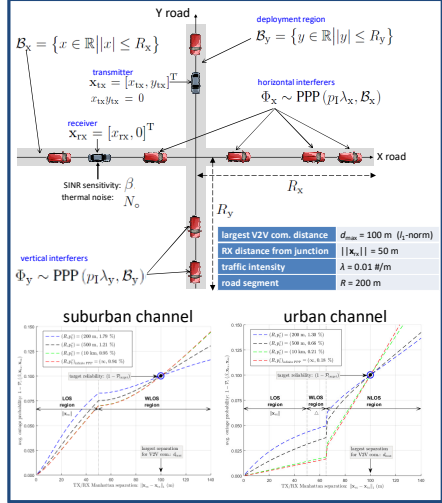


target reliability	$\mathcal{P}_{\text{target}} = 0.9$
transmit power	$P_0 = 20$ dBmW
AWGN floor	$N_0 = -99$ dBmW
RX sensitivity	$\beta = 8$ dB

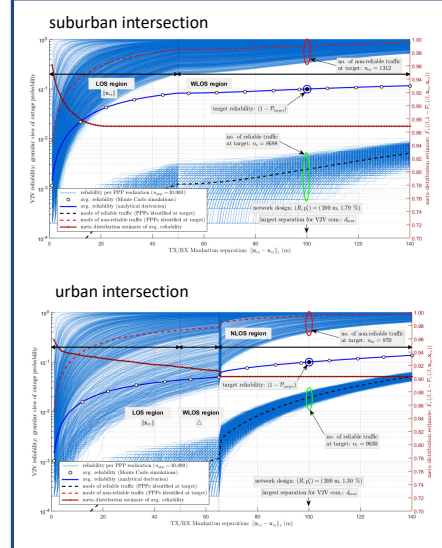
## Channel Propagation



## Average Reliability



## Fine-Grained Reliability



## Conclusion

Metrics for packet reliability are necessary for network analysis & design.

Traditional metrics based on averages are not precise enough for ultra-reliable and delay-sensitive applications such as V2x com.

Fine-grained reliability per traffic realization reveals a bimodal distribution outcome.

Smaller road-segment "R" results in a more polarized reliability outcome.

This striking revelation would have never been obvious by simply exploring averages for reliability.

