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# Analysis and Categorization of Wireless Communication at Urban Crossroads

Analyse und Kategorisierung von Funkkommunikation an städtischen Kreuzungen

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Supported by:



on the basis of a decision  
by the German Bundestag

Crossroad Categories

Car2X Channel Sounding

IEEE 802.11p Transmission Simulation

Fitting and Modeling

Results

## Project Goal

Value benefit analysis of accident avoidance techniques at urban crossroads

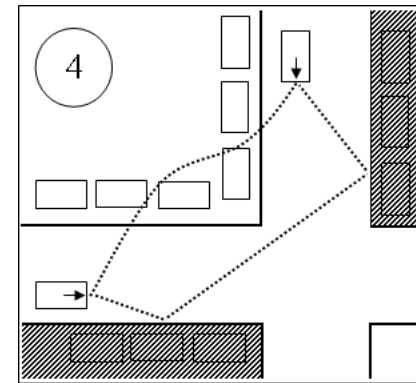
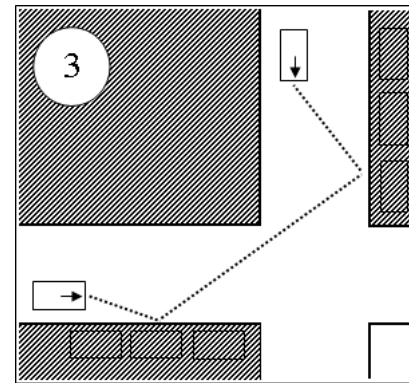
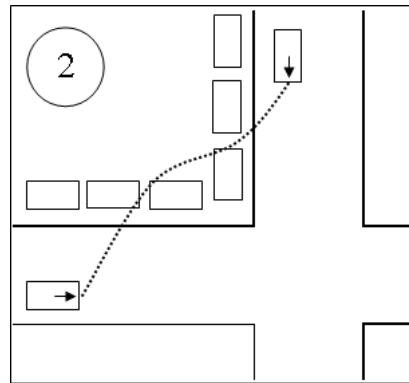
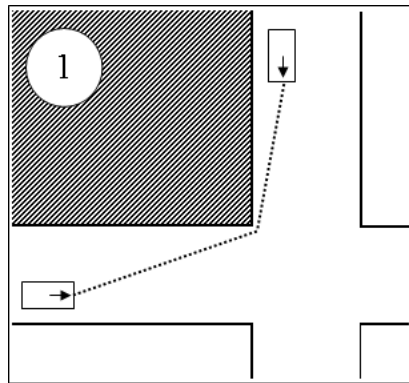
Opponent detection using car-to-car communication

## Task of HHI

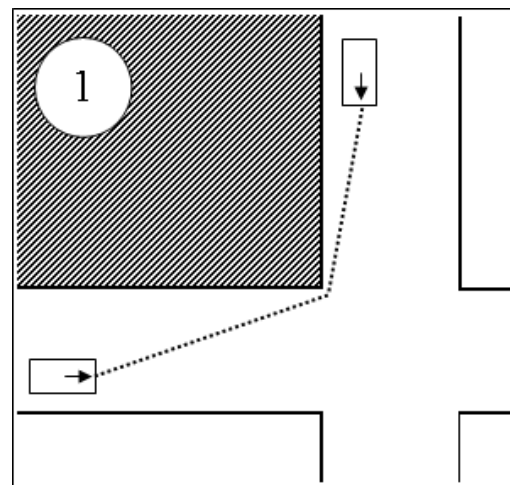
Evaluation of communication performance at urban crossroads



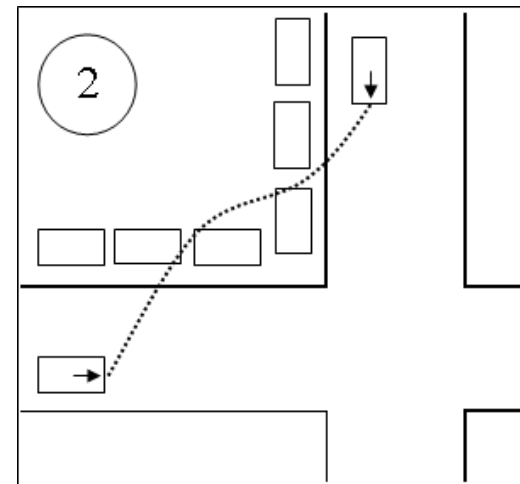
# Initial Crossroad Categories



- Massive obstruction
- No large surfaces available for reflections "to destination"
- Occasional opportunities for reflection, for example individual vehicles, individual house wall

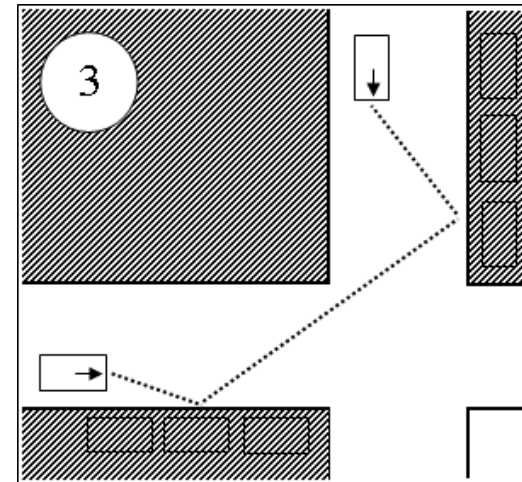


- Line-of-Sight (LoS) obstruction by parked vehicles or vegetation
- No large surfaces available for reflections "to destination"
- Occasional opportunities for reflection, for example individual vehicles, individual house wall



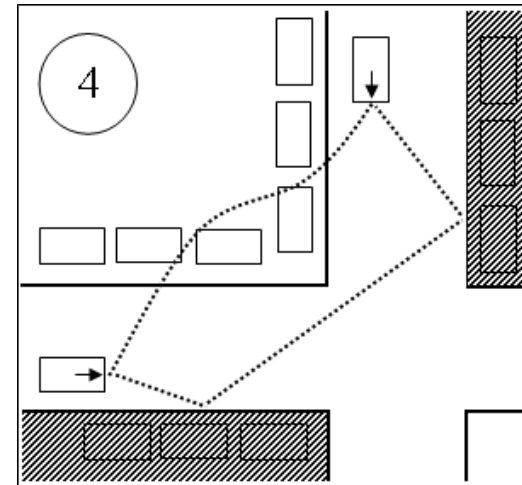


- Massive LoS obstruction
- Large surfaces available for reflections "to destination"
- Reflection surfaces e.g. through walls of houses or parked vehicles



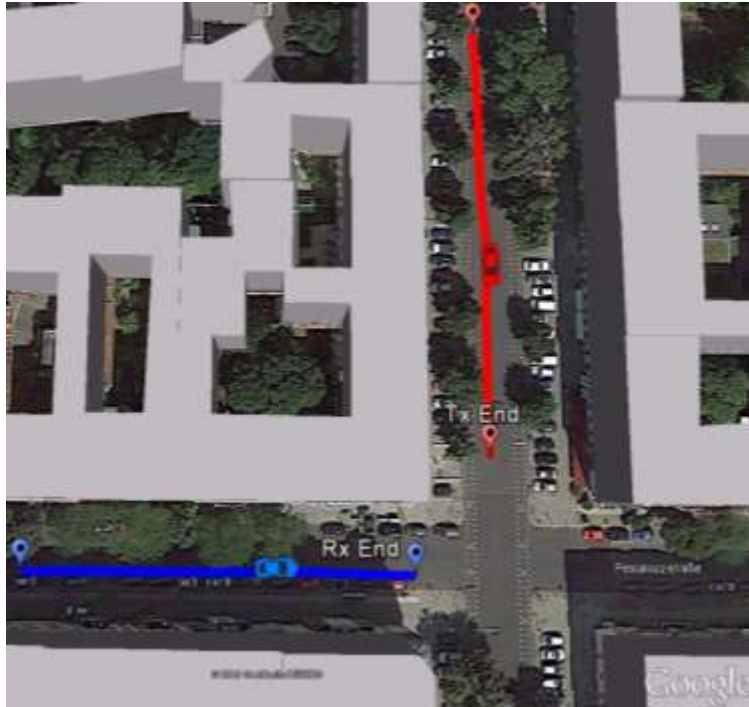


- LoS obstruction by parked vehicles or vegetation
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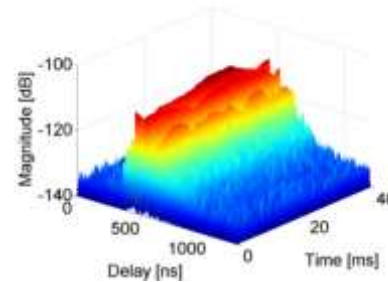
# Measurement Campaign in Berlin



# Car2X Channel Sounder



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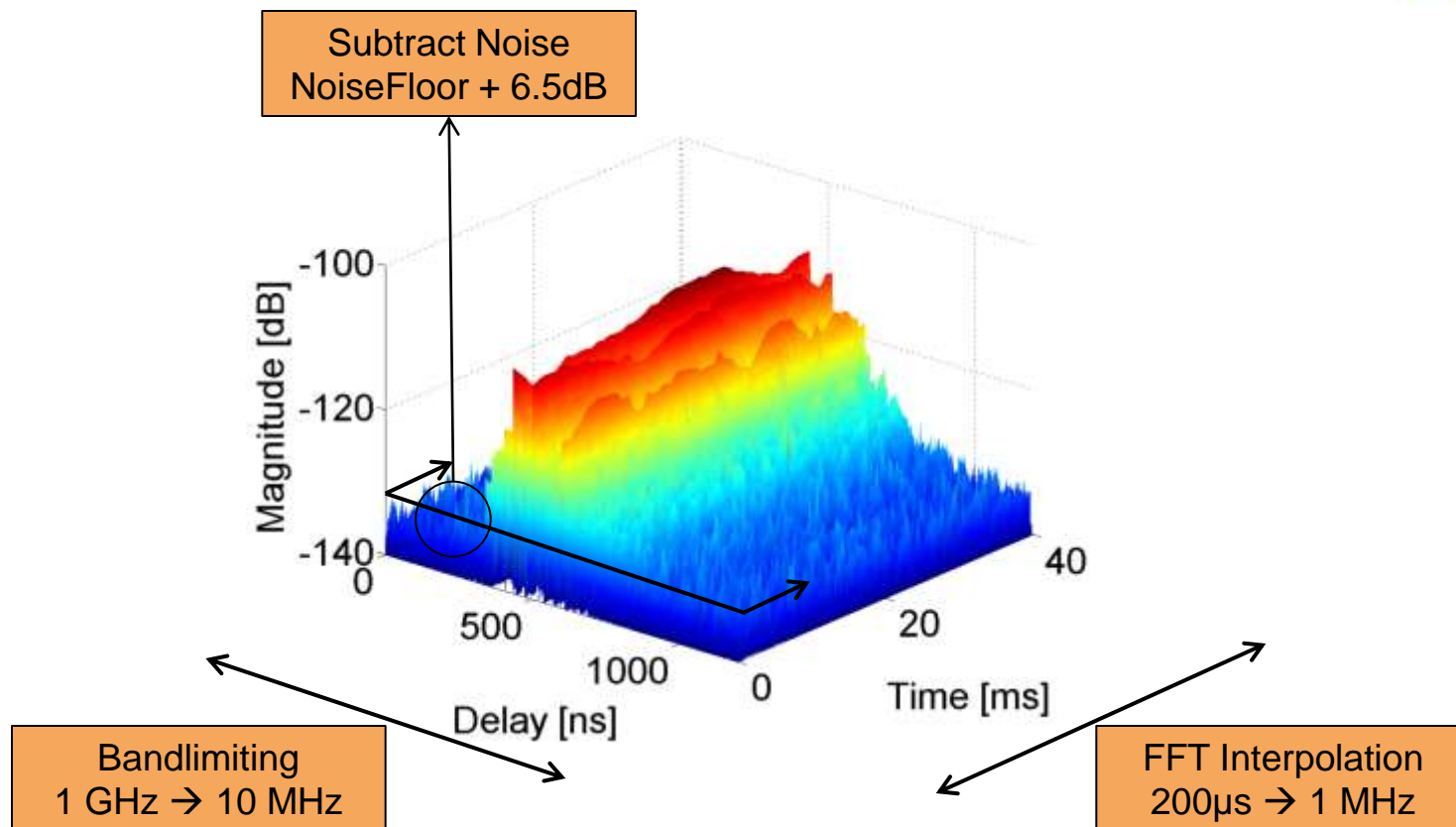


Time-variant  
Channel Impulse  
Response

# Car2X Channel Sounder Measurements



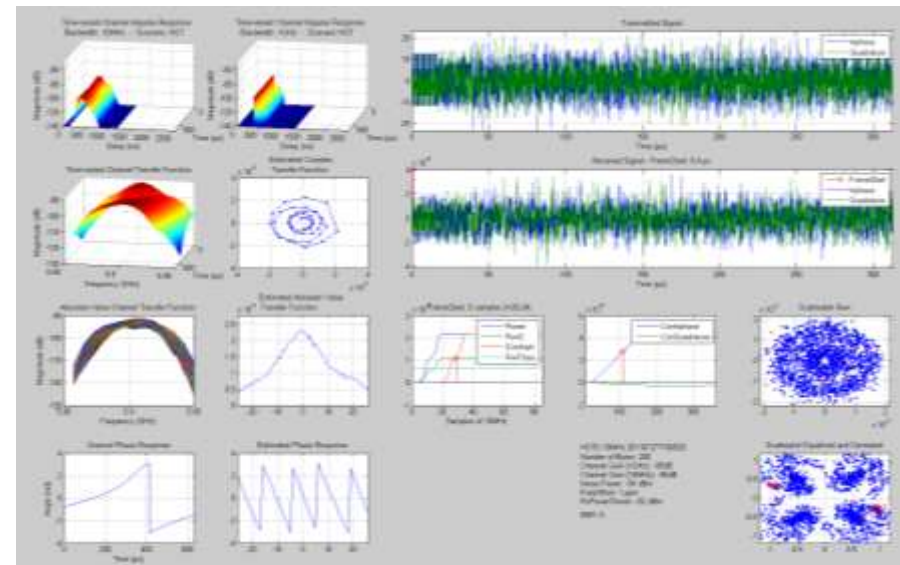
# Processing of Channel Sounder Data



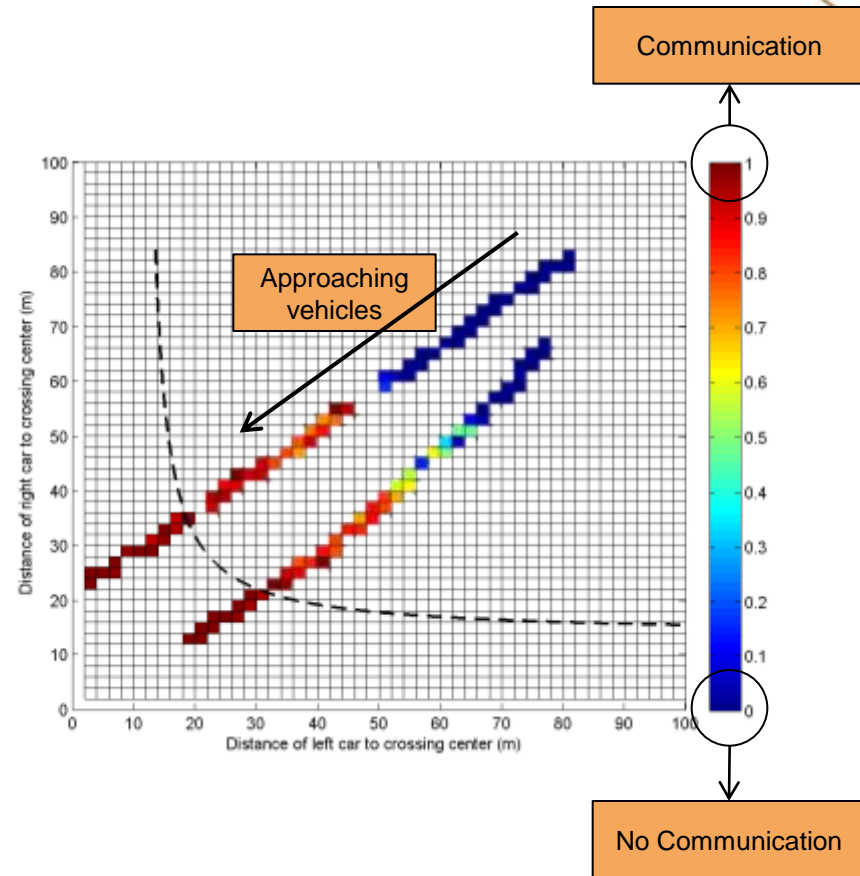
# IEEE 802.11p Transmission Simulations



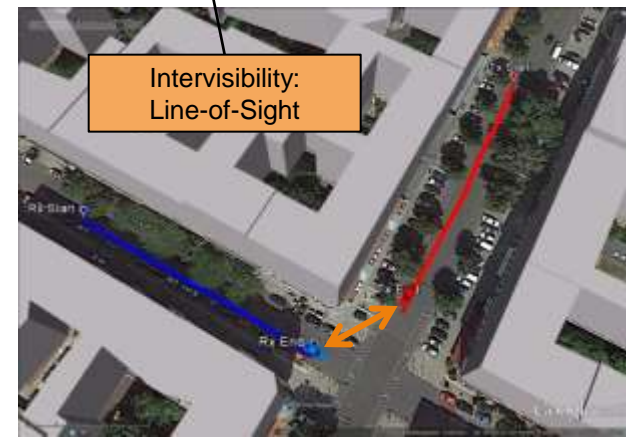
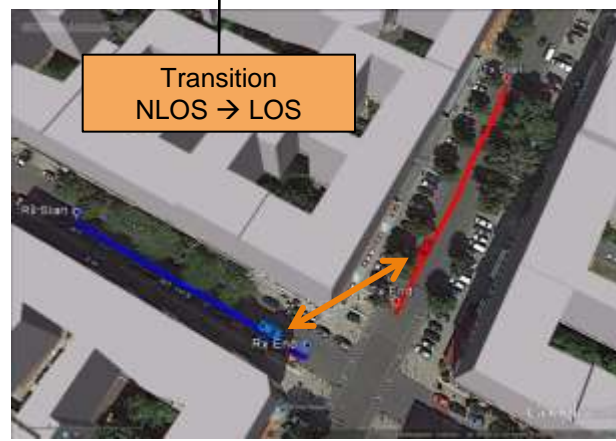
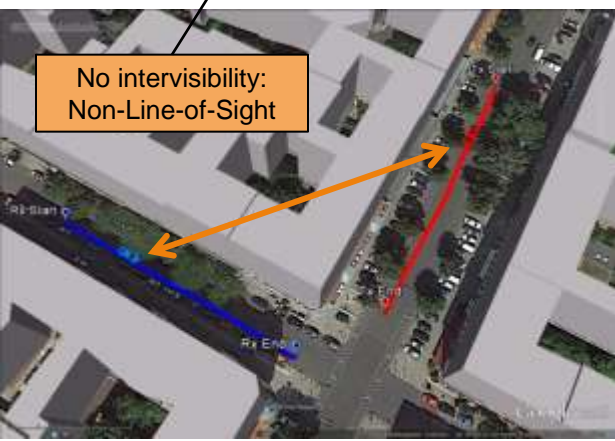
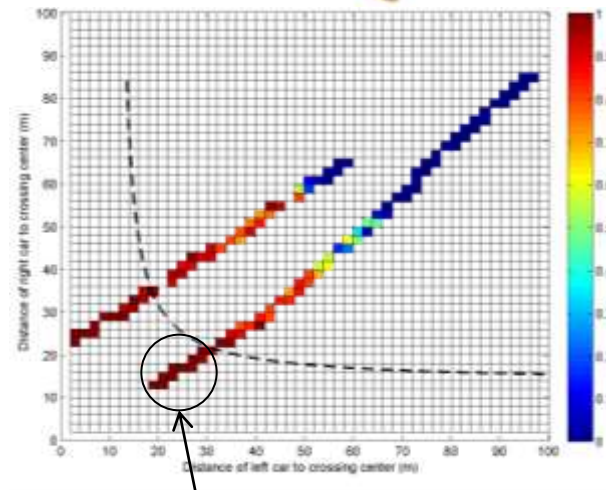
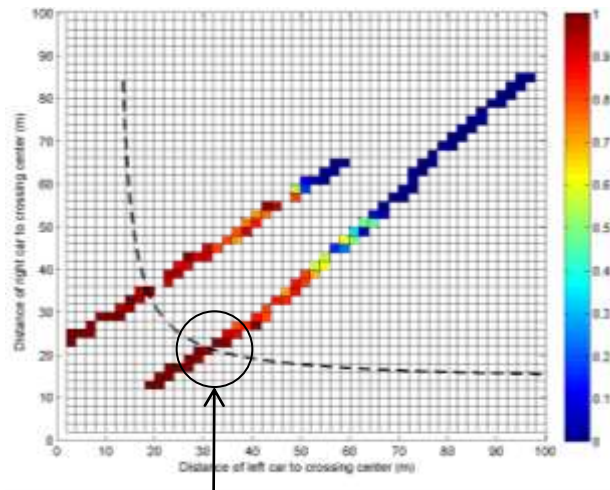
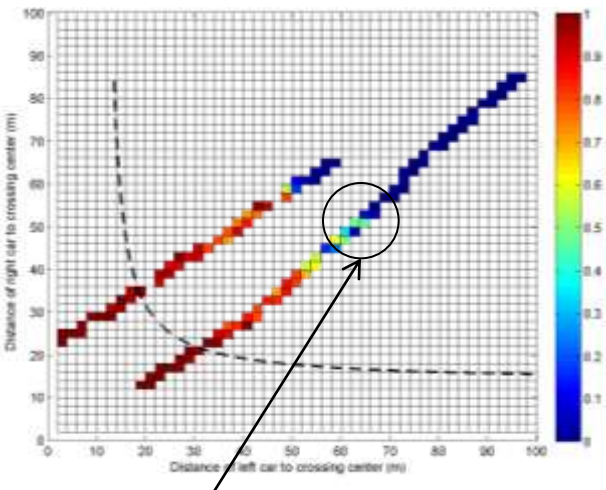
- Carrier frequency: 5.9 GHz
- Bandwidth: 10 MHz
- Packet size: 200 Bytes
- Frequency offset: 1 ppm
- Tx Power: 20 dBm
- Antenna Gain: 2 dB
- Noise Power: -94 dBm
- Rx Power Threshold: -82 dBm
- Viterbi decoder: hard decision, terminated



# Transmission Simulation Results



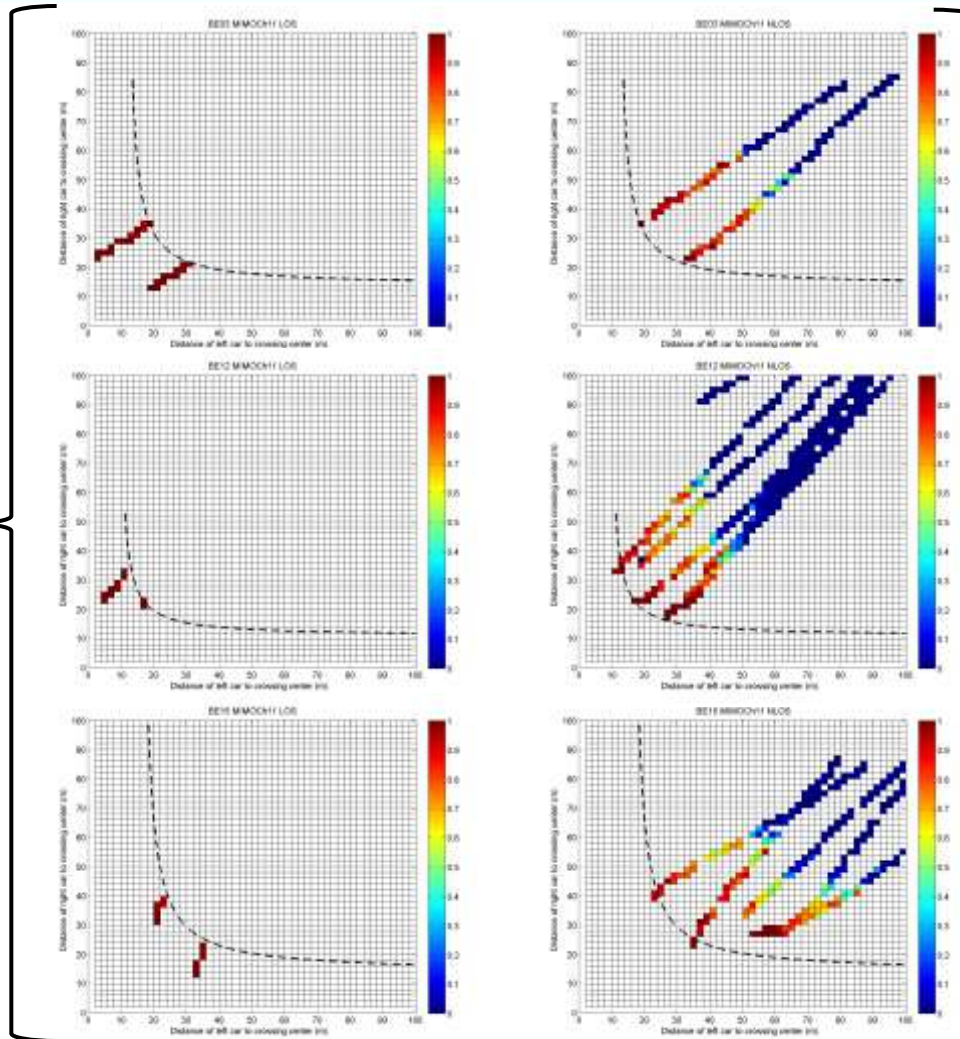
# Transition from NLoS to LoS



# Superposition of Crossroads Results



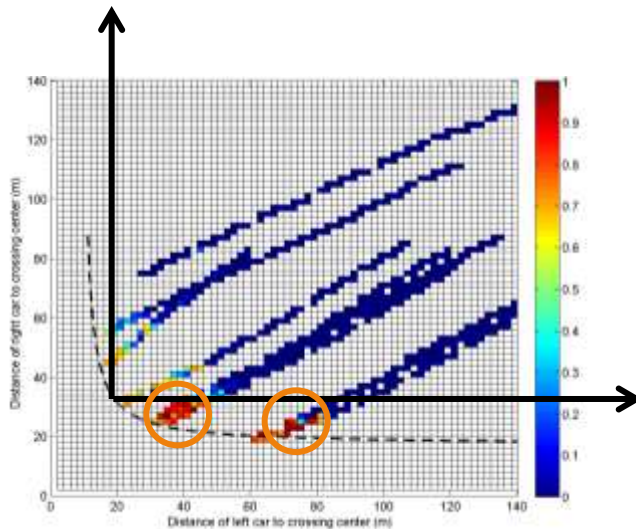
**Line of Sight**  
 Quasi-location-independent communication performance  
 → **Arithmetic Average**



**Non Line of Sight**  
 Different sizes of crossroads challenge superposition  
 → ?



# Transformation of Coordinates

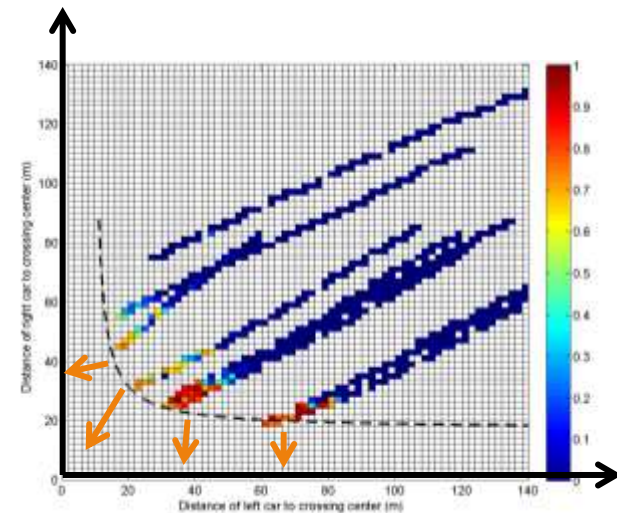


## Advantage

→ No deformation of results

## Disadvantage

→ Neglect of results



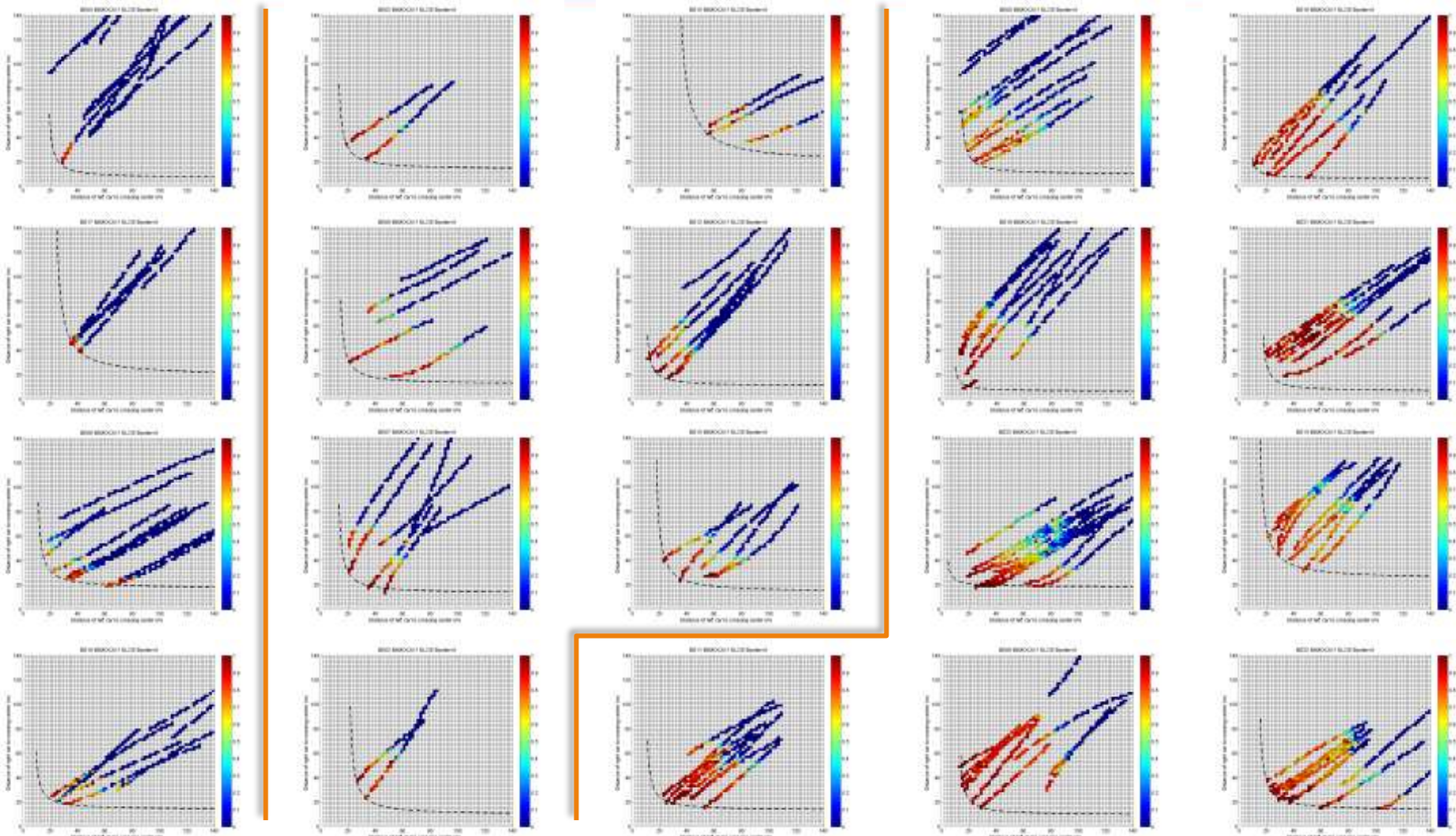
## Advantage

→ No neglect of results

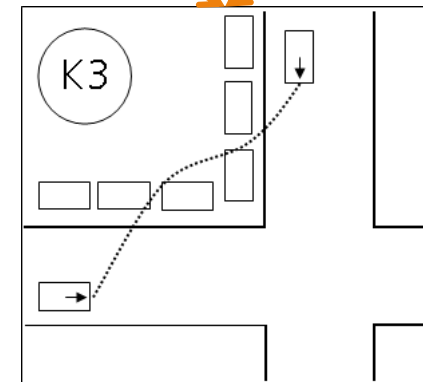
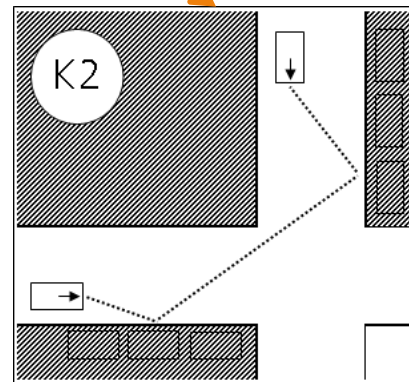
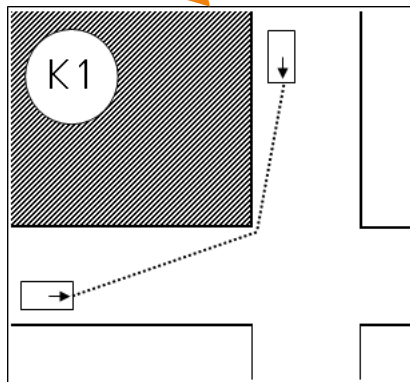
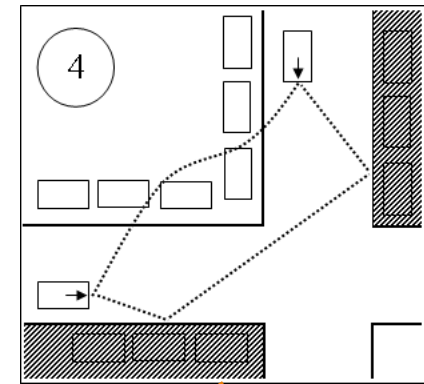
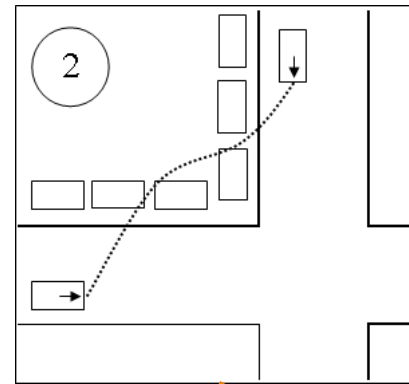
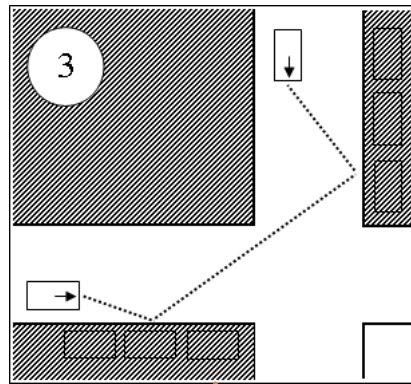
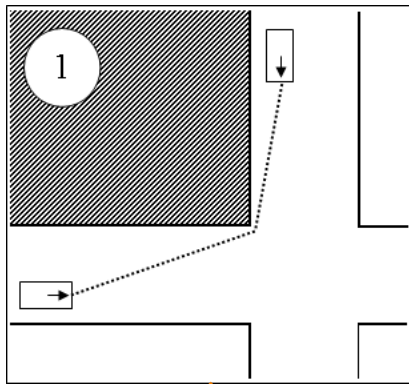
## Disadvantage

→ Deformation of results

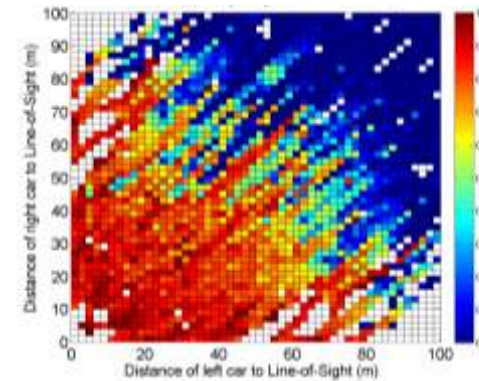
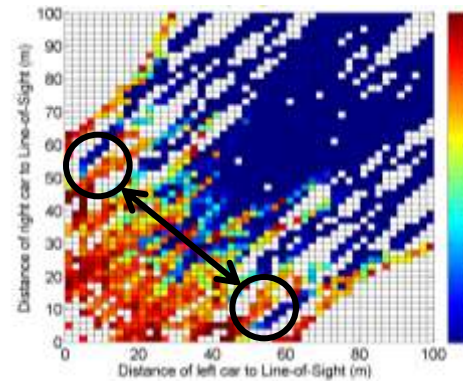
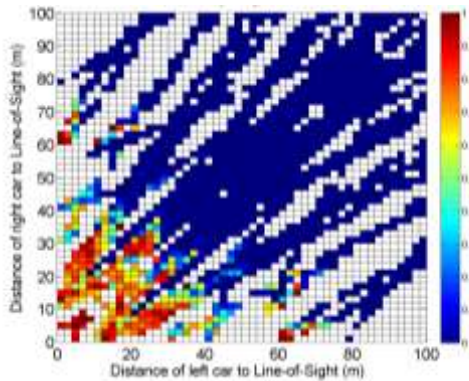
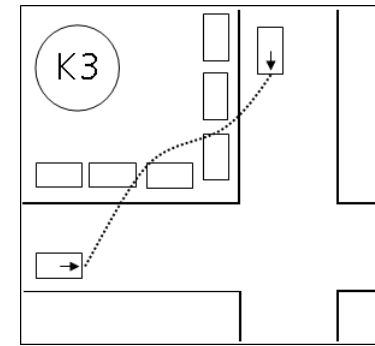
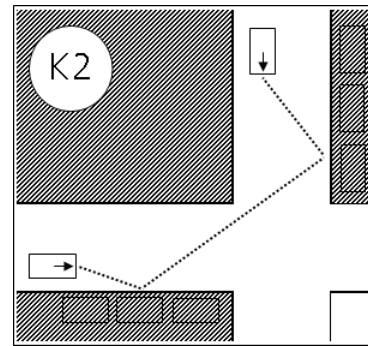
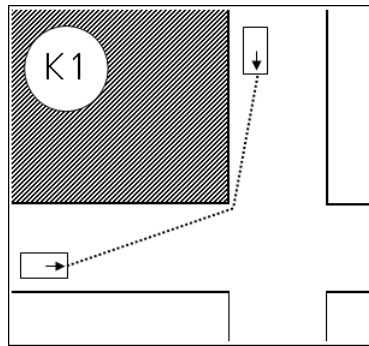
# Group Simulation Results



# Revise Categories

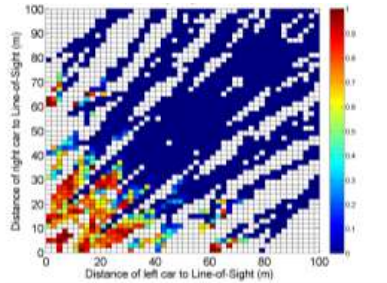


# Superimposed Results

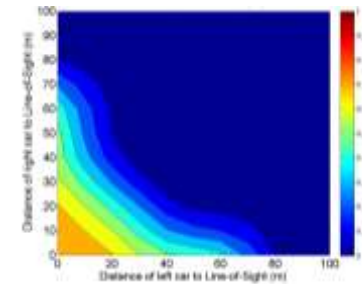


Assumption:  
Symmetrical behavior

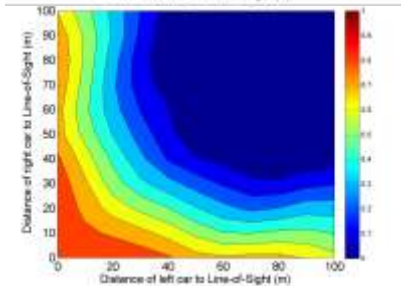
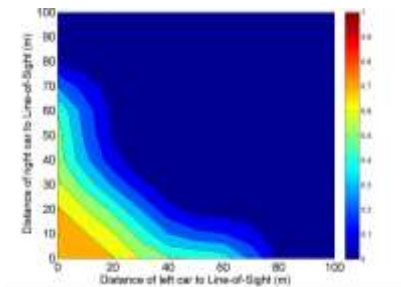
# Fitting and Modeling



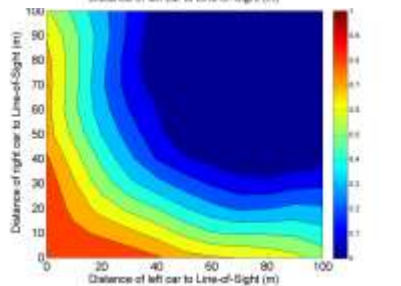
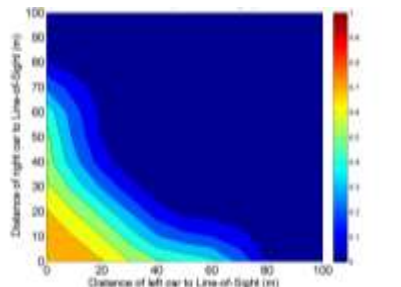
Fitting using a modified *ridge estimator*, where bias is toward smoothness



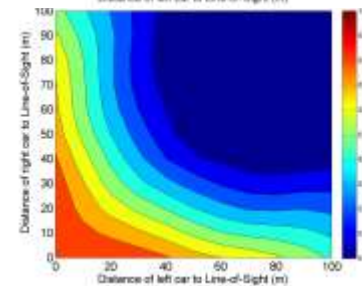
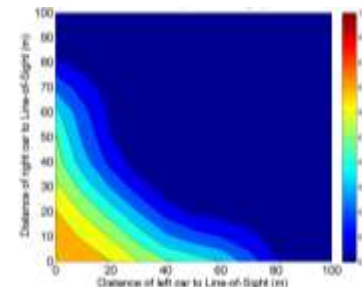
Smoothness  
100



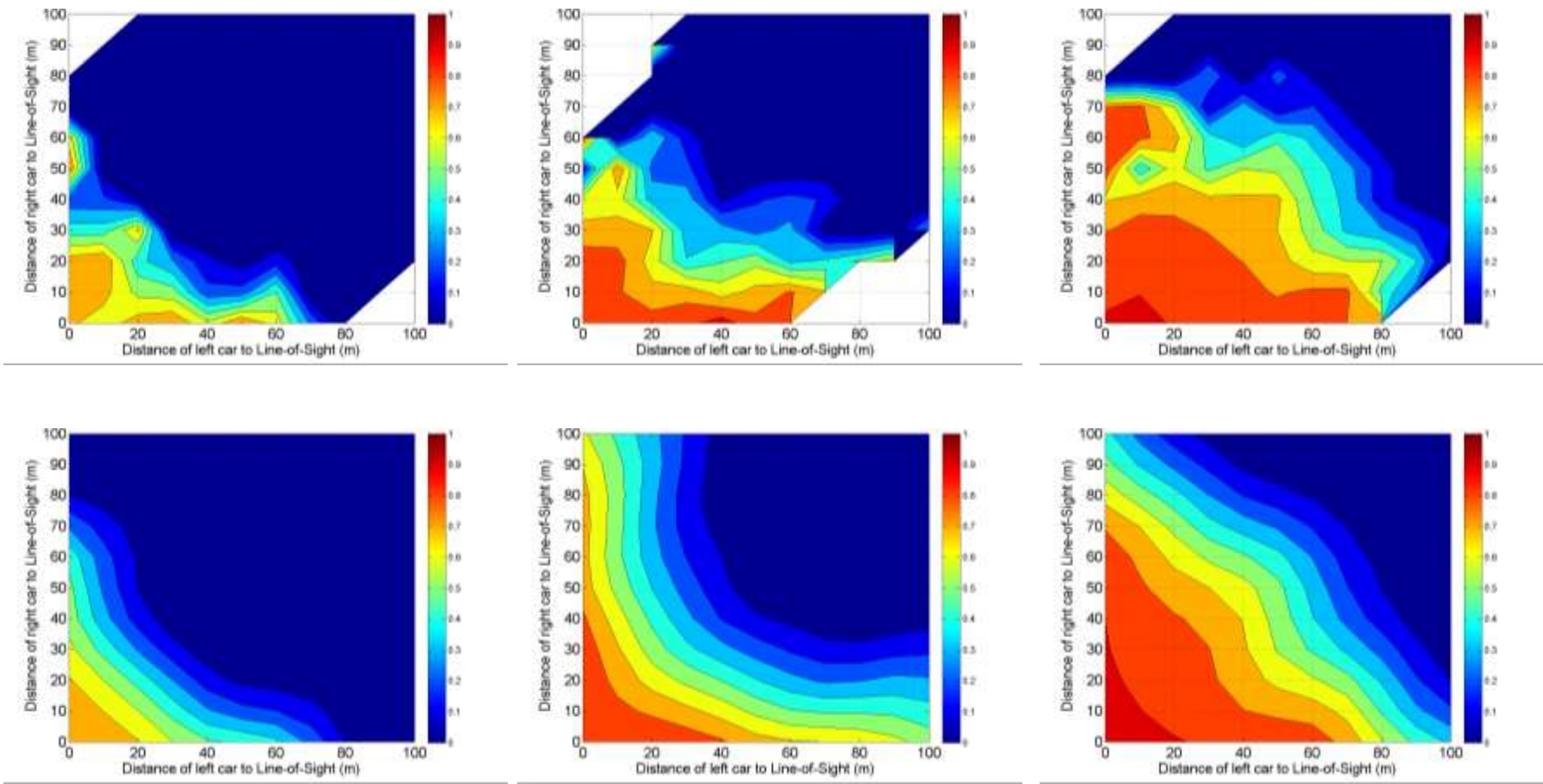
Smoothness  
120



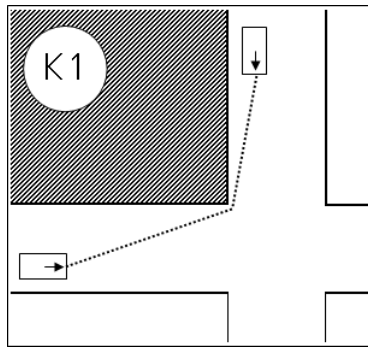
Smoothness  
150



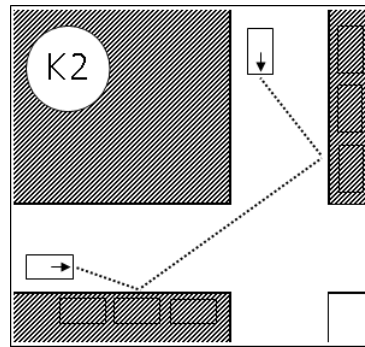
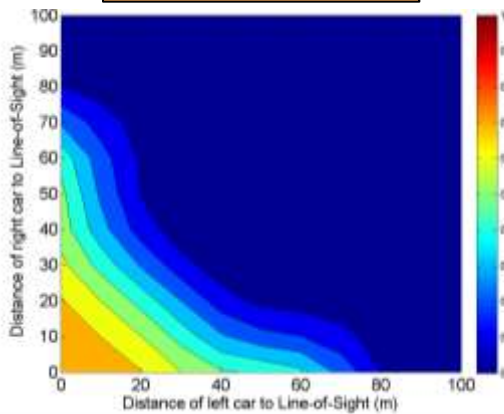
# Superimposed Only vs. Fitting and Modeling



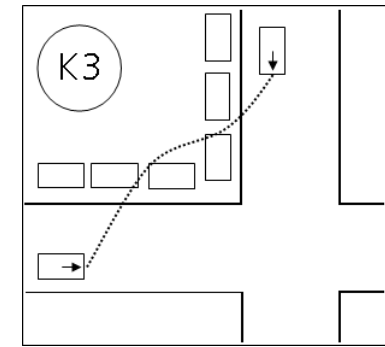
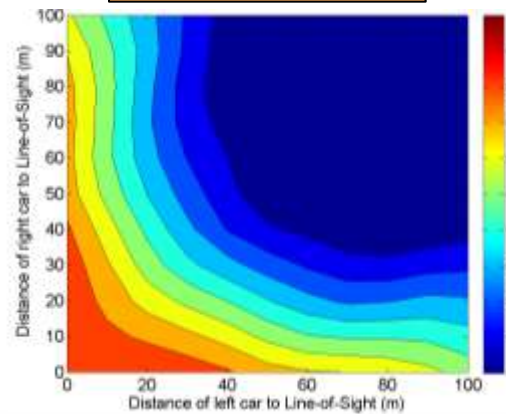
# Final Results



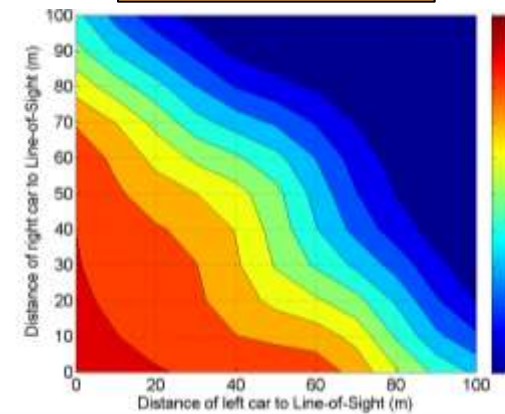
PDR(LOS) = 0.92



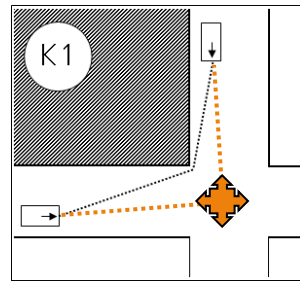
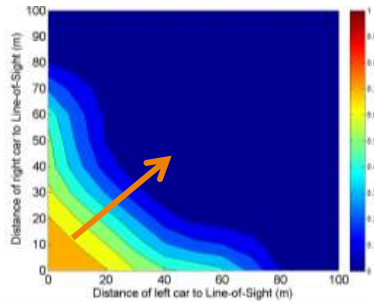
PDR(LOS) = 0.98



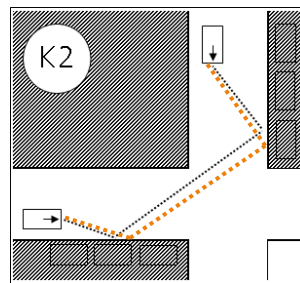
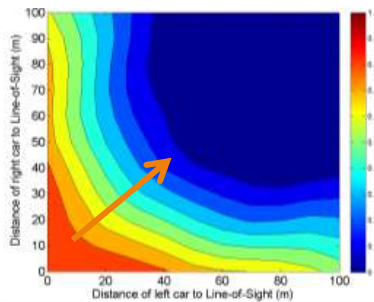
PDR(LOS) = 0.95



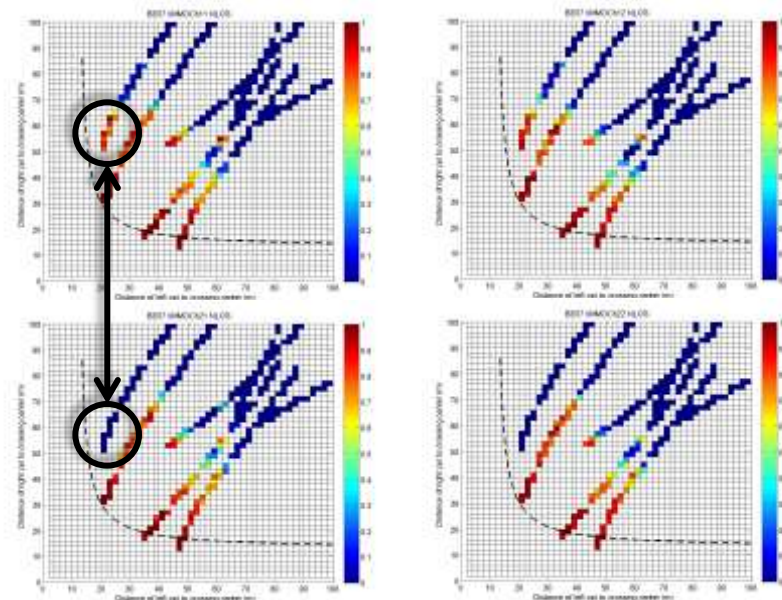
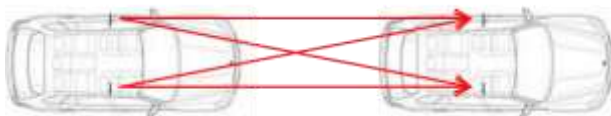
# Room for Improvement



Repeater at intersections  
with high accident probability



More reliable communication  
with **MIMO** techniques





Thank you!

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