# V2X COMMUNICATIONS EVALUATION

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C2C Week

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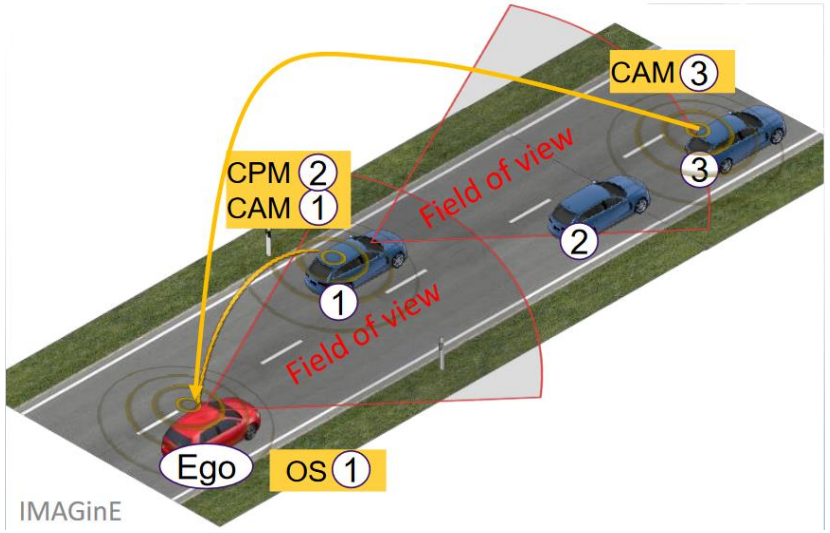
DLR

# Communication Requirements




## Collective Perception Service (CPS): Packet size/reliability example

CPM: Send out detected objects including all vehicles on road, including VRUs on road and road-side. Up to 25 objects in Urban and 10 in Highway included. Security included.

| Highway | Min | Max | average |
|---|---|---|---|
| Package size [byte] | 400 | 850 | 625 |
| Relevance distance [m] | 300 m @ 99,9% | 500 m @ 80% | |

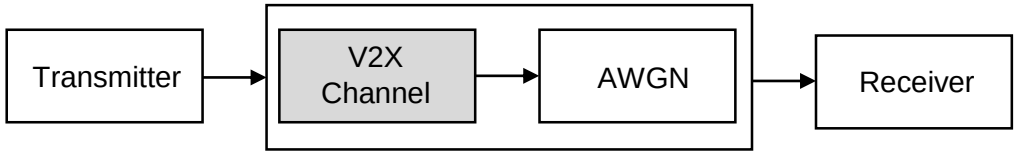
| Urban / suburban | Min | Max | average |
|---|---|---|---|
| Package size [byte] | 400 | 1450 | 925 |
| Relevance distance [m] | Urban 50km/h: 25 m @ 99,9% | 200 m @ 80% | |

Source: package sizes and package elements measured in IMAGinE
Comparable message sizes, relevance distances also in 5GAA „C-V2X Use cases and Service Level Requirements Volume III“

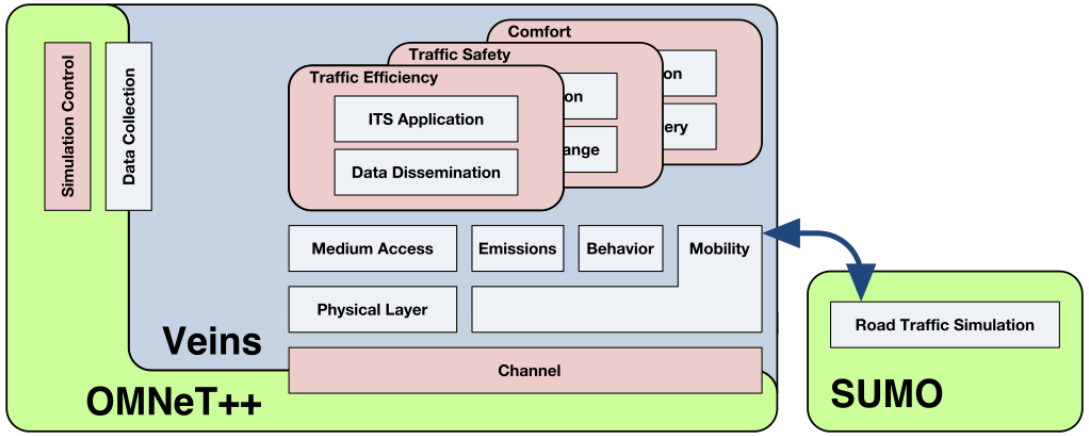
**Next step:** Evaluate future communication technologies with the CPS and MCS requirements.

# Communication Evaluation

- Link-level evaluation
  - Simulation environment: MATLAB
  - Different packet sizes, modulation and coding schemes, Tx power, etc.
  - Results: e.g. Packet error rate (PER), communication range
  - Requires: realistic channel models

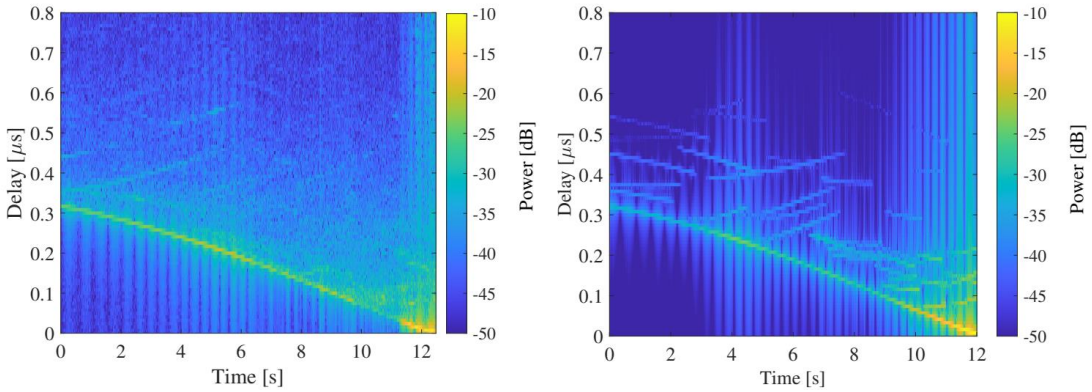



- System-level evaluation
  - Network and traffic simulators
  - Different traffic and channel usage conditions, etc.
  - Results: PER, end-to-end delay (E2E), channel busy ratio, etc.
  - Requires: accurate PER and path loss models



# Channel models

1. AWGN channel
2. Stochastic channels
   - Example: Tapped-delay line (TDL)
   - Relatively low complexity and easy to use.
   - Assume WSSUS, and don't include geometry
3. Geometry-based stochastic channel models (GSCM)
   - Examples: WINNER II, and COST 2100
   - Well suited for non-stationary environments, e.g. vehicular
   - Include Tx, Rx, and scatterrers motion




Measured channel

Simulated channel

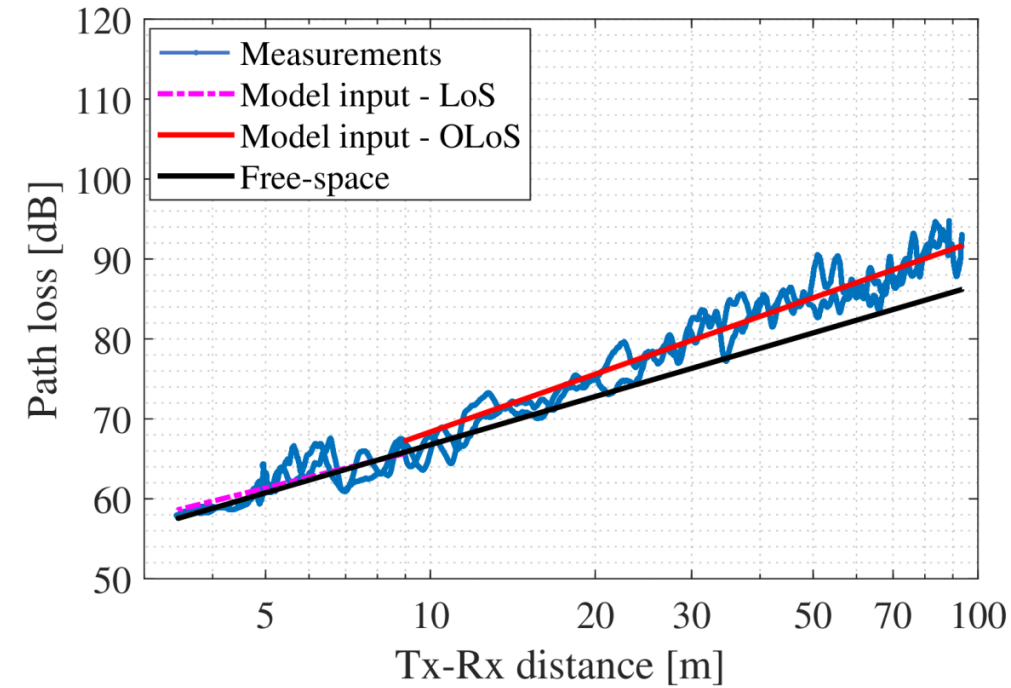
TDL parameters

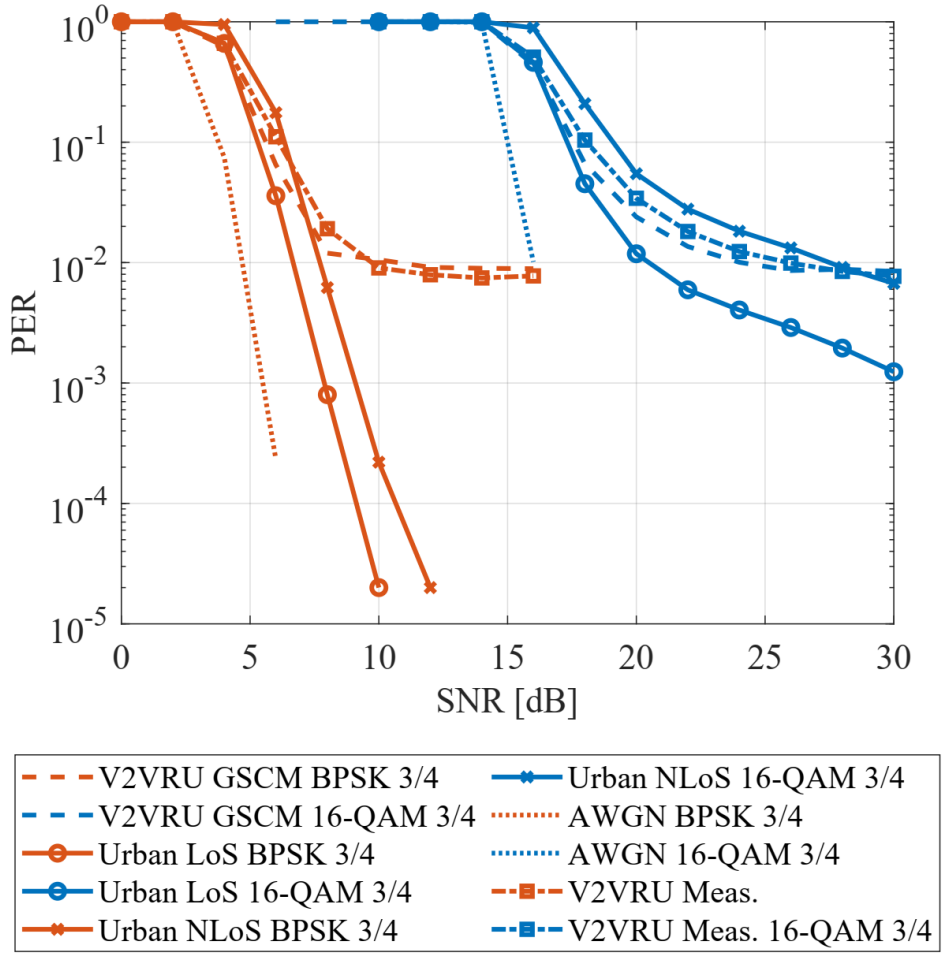
| Scenario | Path Delays [ns] | Path Gains [dB] | Doppler Shift [Hz] |
|---|---|---|---|
| Urban LoS | [0, 117, 183, 333] | [0, -8, -10, -15] | [0, 236, -157, 492] |
| Urban NLoS | [0, 267, 400, 533] | [0, -3, -5, -10] | [0, 295, -98, 591] |

GSCM parameters

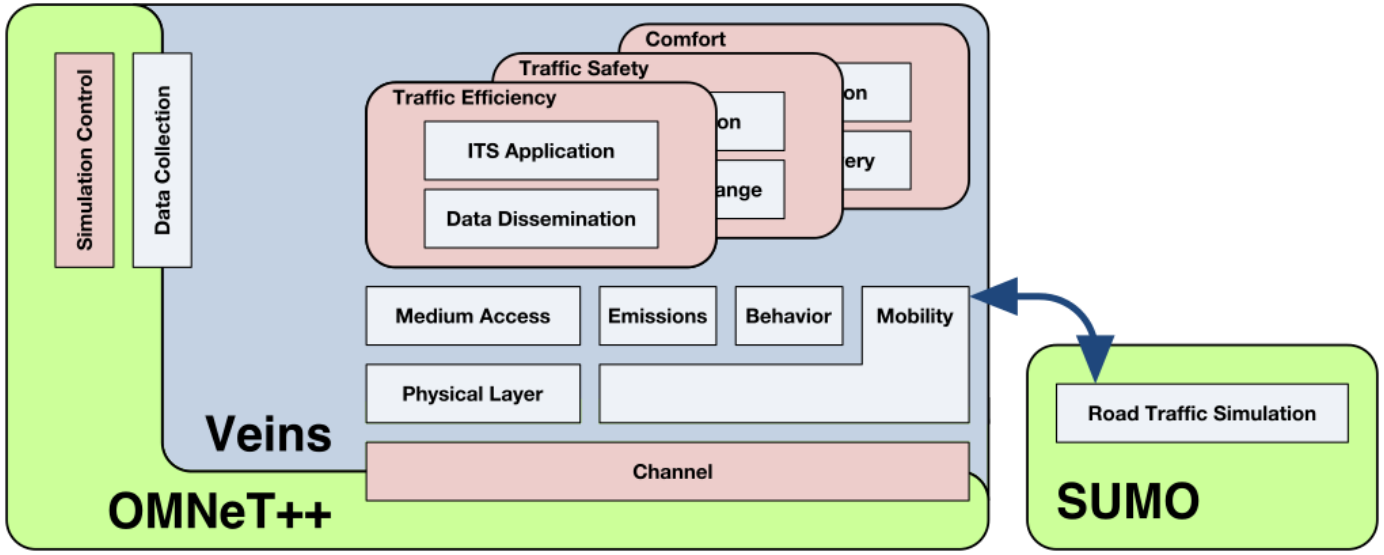
| Parameters | | Scenario 2 LoS | Scenario 2 OLoS |
|---|---|---|---|
| SF [dB] | $\mu$ | 0 | 0 |
| | $\sigma$ | 1.80 | 1.80 |
| Corr.distance [m] | $d_c$ | 2.27 | 2.27 |
| K-factor [dB] | $\mu$ | 16.22 | 5.34 |
| | $\sigma$ | 2.88 | 4.38 |
| Corr.distance [m] | $d_c$ | 4.42 | 30.58 |
| DS [$\log_{10}(s)$] | $\mu$ | -8.19 | -7.60 |
| | $\sigma$ | 0.19 | 0.21 |
| Corr.distance [m] | $d_c$ | 4.42 | 70 |
| ASD [$\log_{10}(^\circ)$] | $\mu$ | 0.86 | 0.86 |
| | $\sigma$ | 0.39 | 0.39 |
| Corr.distance [m] | $d_c$ | 63.23 | 63.23 |
| ASA [$\log_{10}(^\circ)$] | $\mu$ | 1.03 | 1.03 |
| | $\sigma$ | 0.39 | 0.39 |
| Corr.distance [m] | $d_c$ | 66.17 | 66.17 |

# Link-level Evaluation



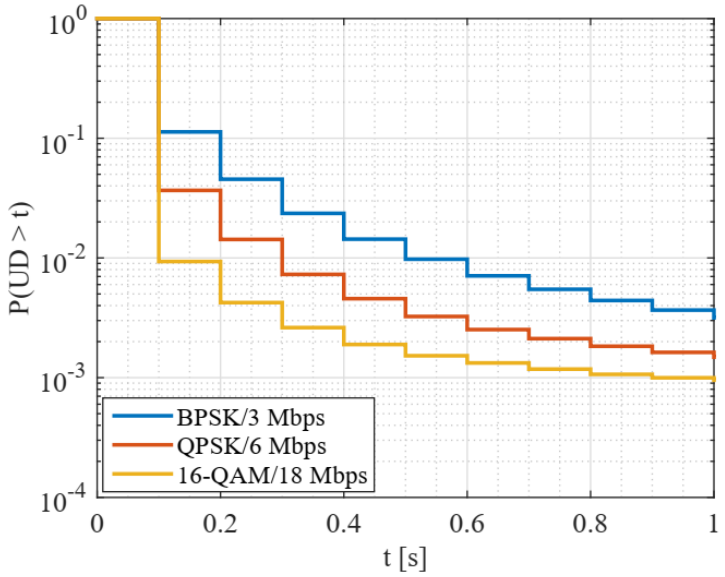



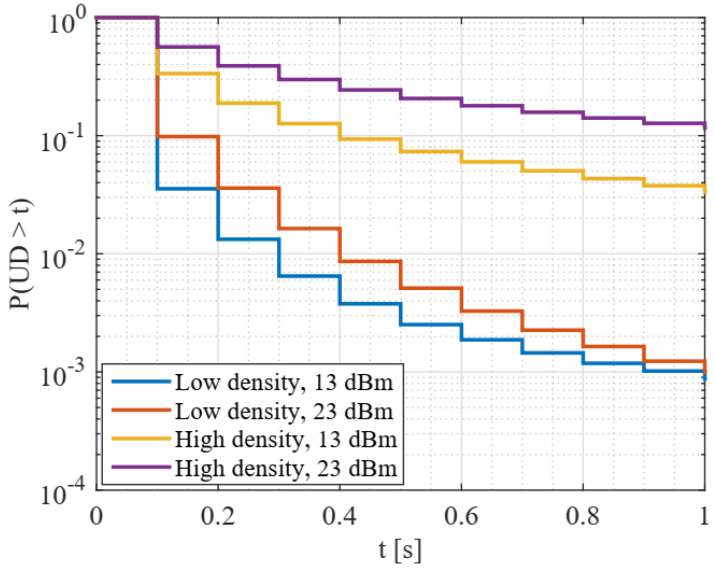
# System-level Evaluation





Update delay (UD)



# KPI

Update Delay (UD) is the time elapsed between two consecutive successfully received packets from specific Tx at  specific Rx.