Intelligent Intersection
The 5G Networked Intersection

Closing Event

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Motivation

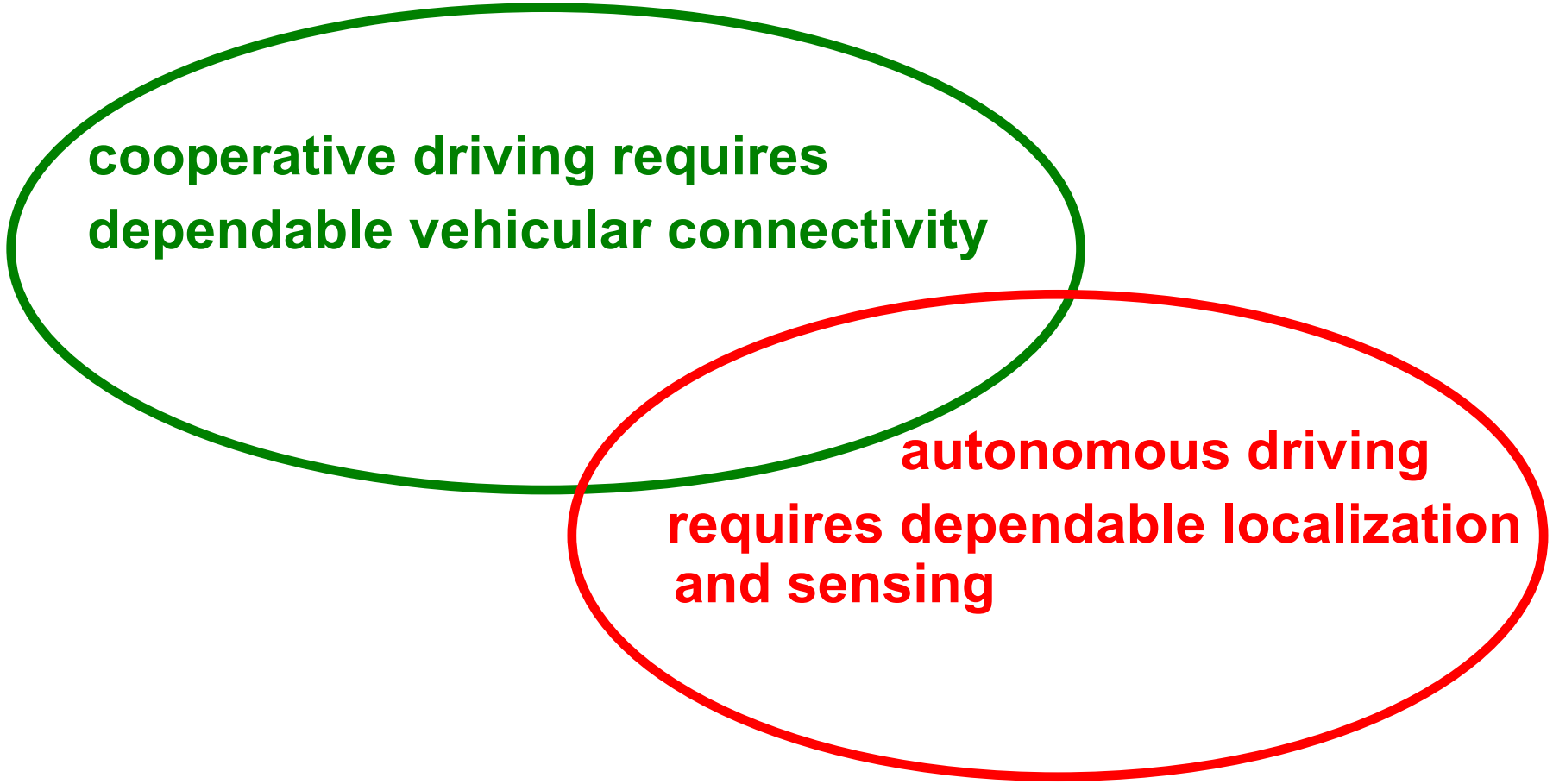
- Collision-Free Automated Urban Driving
  - safety
  - efficiency
  - environmental impact
  - passenger comfort

“Unified, efficient, and accurate solution to the obstacle avoidance problem.”

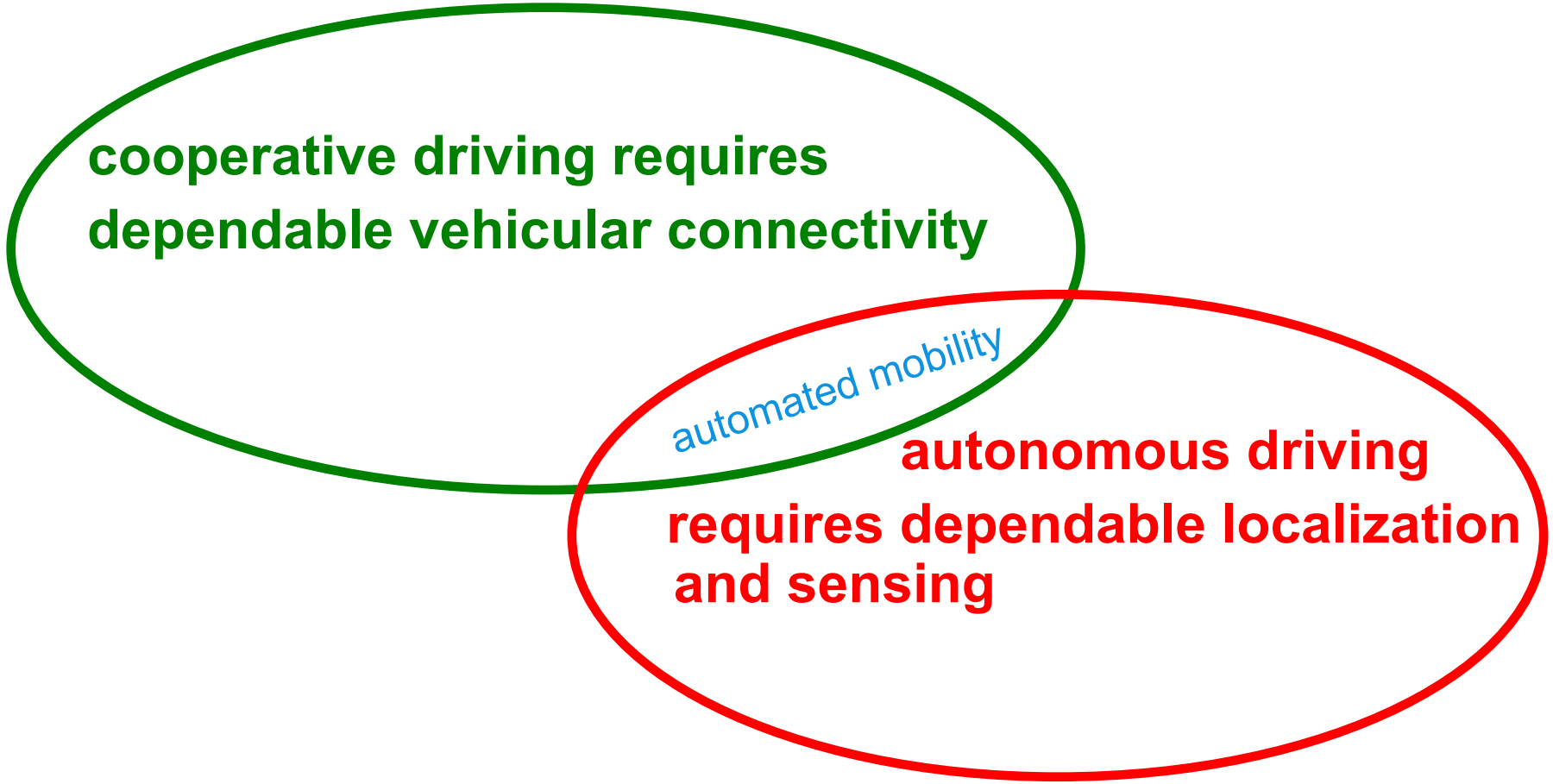
Intelligent Intersection

- **5G dependable connectivity, localization and sensing**
- **Example of smart traffic light system organization**
- **Selected results**
  - 5G Basic safety messages
  - 5G Localization as a service
  - 5G Cooperative perception
- **Summary and outlook**

5G dependable connectivity, localization and sensing

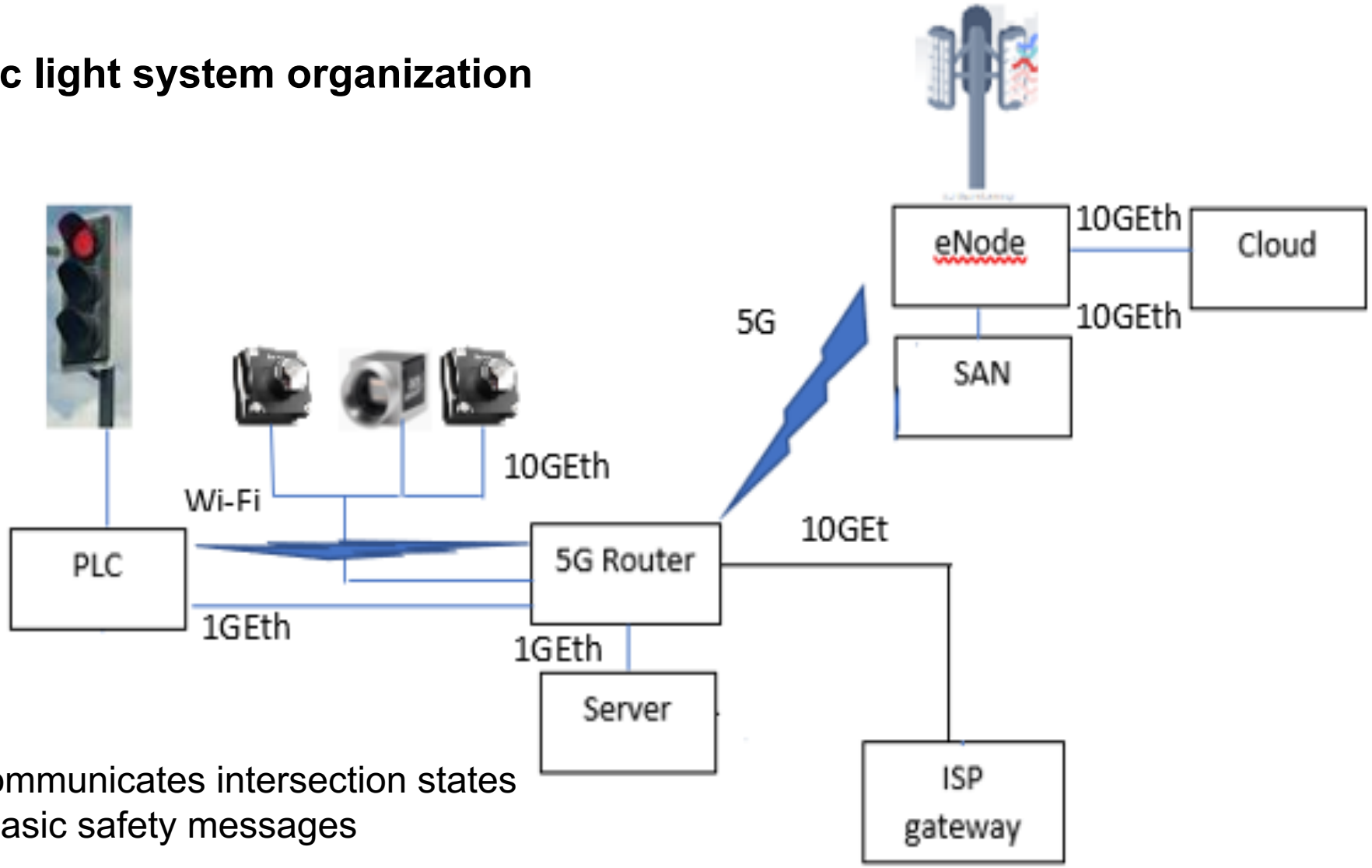


5G dependable connectivity, localization and sensing



5G Internet of Things Architecture

Example of Smart traffic light system organization

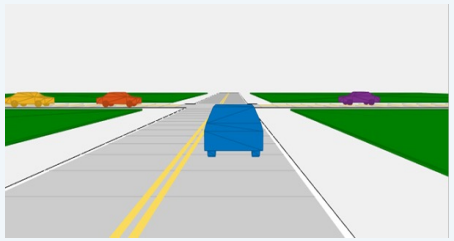


5G Role:

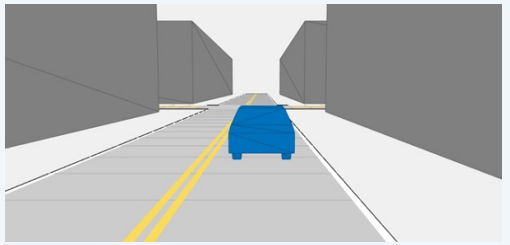
- eNode controls and communicates intersection states
- eNode disseminates basic safety messages

5G Basic Safety Message Transmission – Vehicle-to-Vehicle

Propagation Modelling for Intersection ⟺ **Intersection Scenario Models**



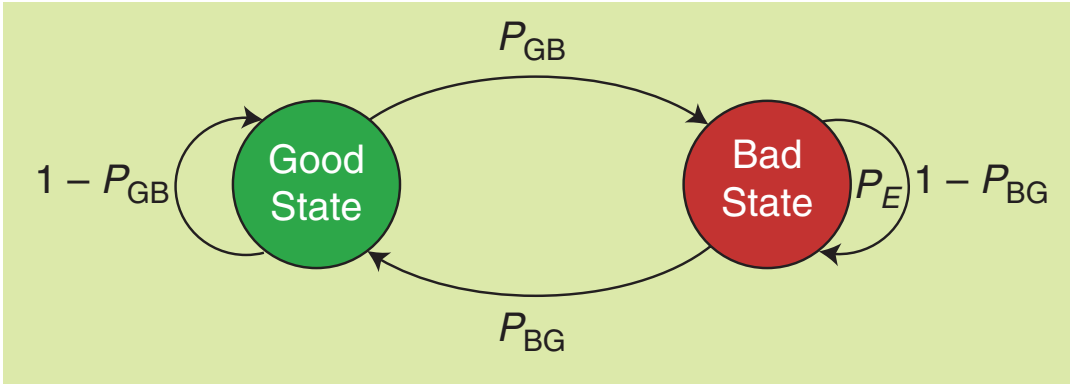
Scenario A: The perspective of vehicle 1



Scenario B: The perspective of vehicle 1

Basic Safety Message Transmission ⟺ **Vienna 5G Simulator**

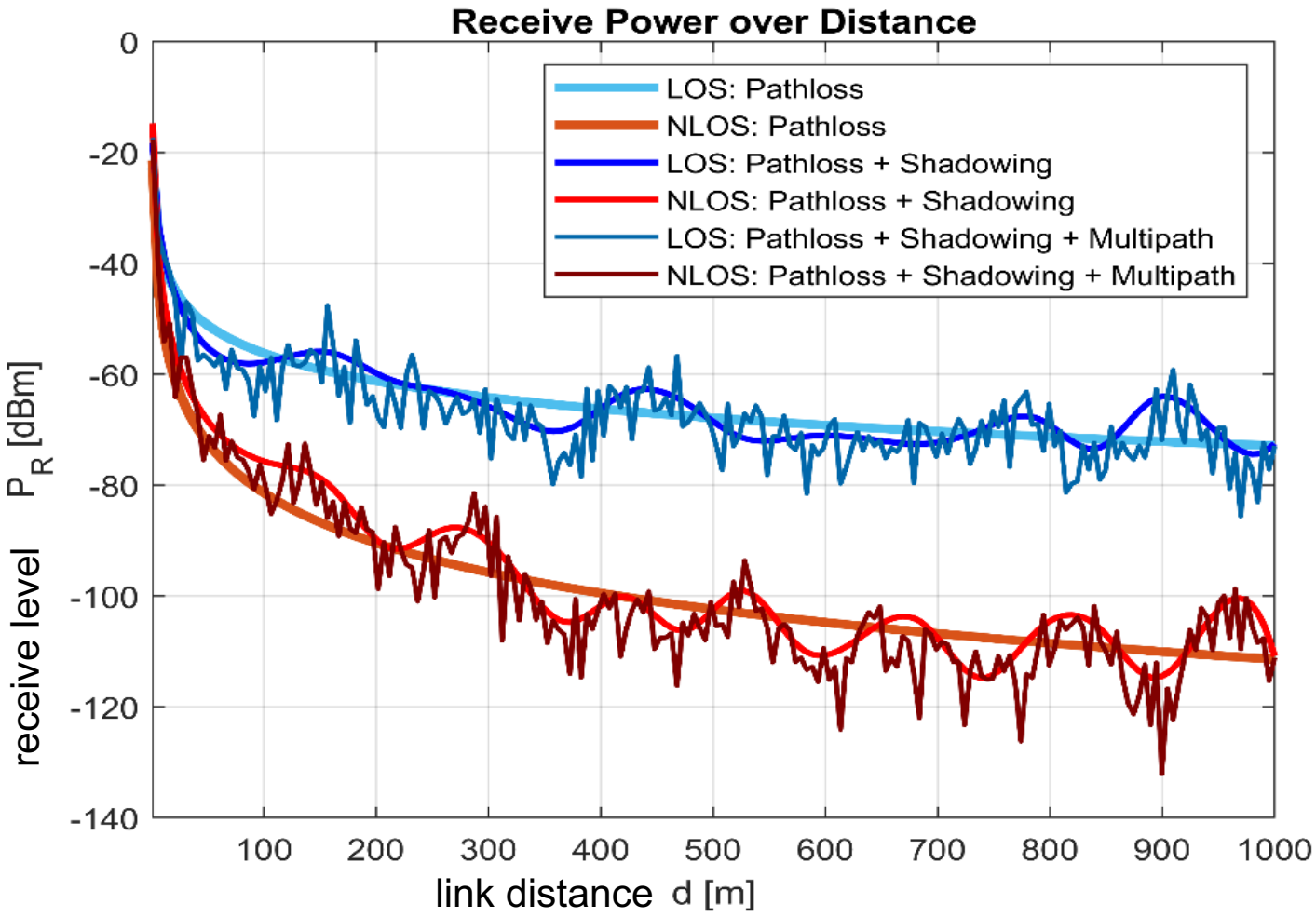
Gilbert-Elliot Packet Error Model ⟺



5G ITS Key Assumptions / Parameters

Parameter	Value
Carrier frequency	5.9 GHz
Bandwidth	4.32 MHz
Subcarrier spacing	60 kHz
Number of OFDM symbols	14
Transmit power	100 mW
Noise Figure	9 dB
Vehicle speed	60 km/h
Doppler spectrum model	Jakes
Modulation and coding scheme (MCS)	64-QAM 873/1024
Forward Error Correction	Turbo-Code

Pathloss, Shadowing, Multi-Path



Basic Safety Message Specification (SAE J2735)

Parameter	Abbreviation	Bytes
sequence number for a stream of messages	MsgCount	1
random device identifier	TemporaryId	4
time at which the position was determined	DSecond	2
geographical latitude of the vehicle	Latitude	4
geographic longitude of the vehicle	Longitude	4
geographical elevation	Elevation	2
Genauigkeit der Positionsbestimmung	PositionalAccuracy	4
accuracy of the position determination	TransmissionState	2
speed of the vehicle	Speed	2
current course of the vehicle	Heading	2
angle of the driver's steering wheel	SteeringWheelAngle	1
acceleration of the vehicle in three directions	AccelerationSet4Way	7
current status of brakes and system control	BrakeSystemStatus	2
length and width of the vehicle	VehicleSize	3

40 Byte of Information Content = 320 bit per BSM

Error Probabilities for 5G Transmission of BSM Messages

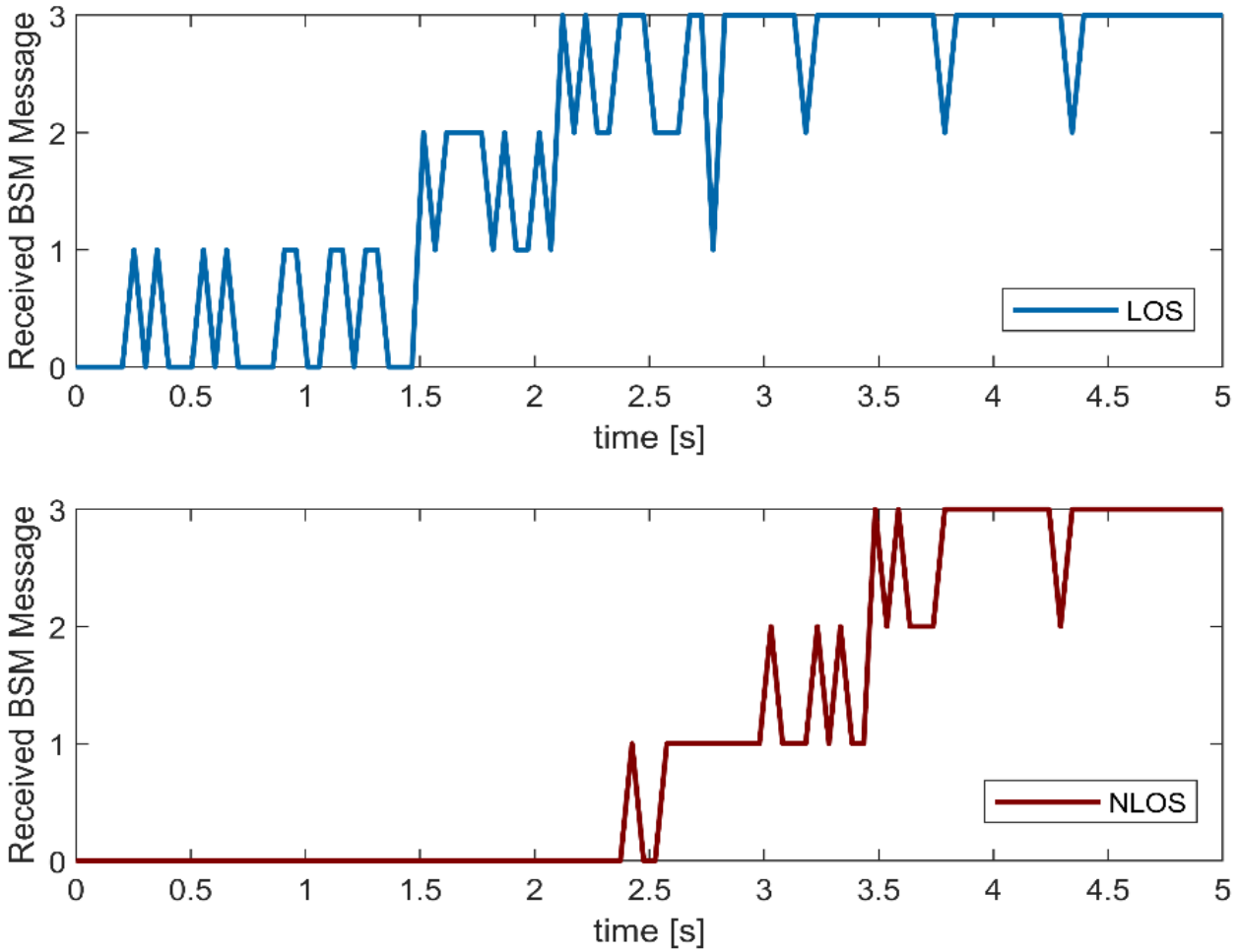
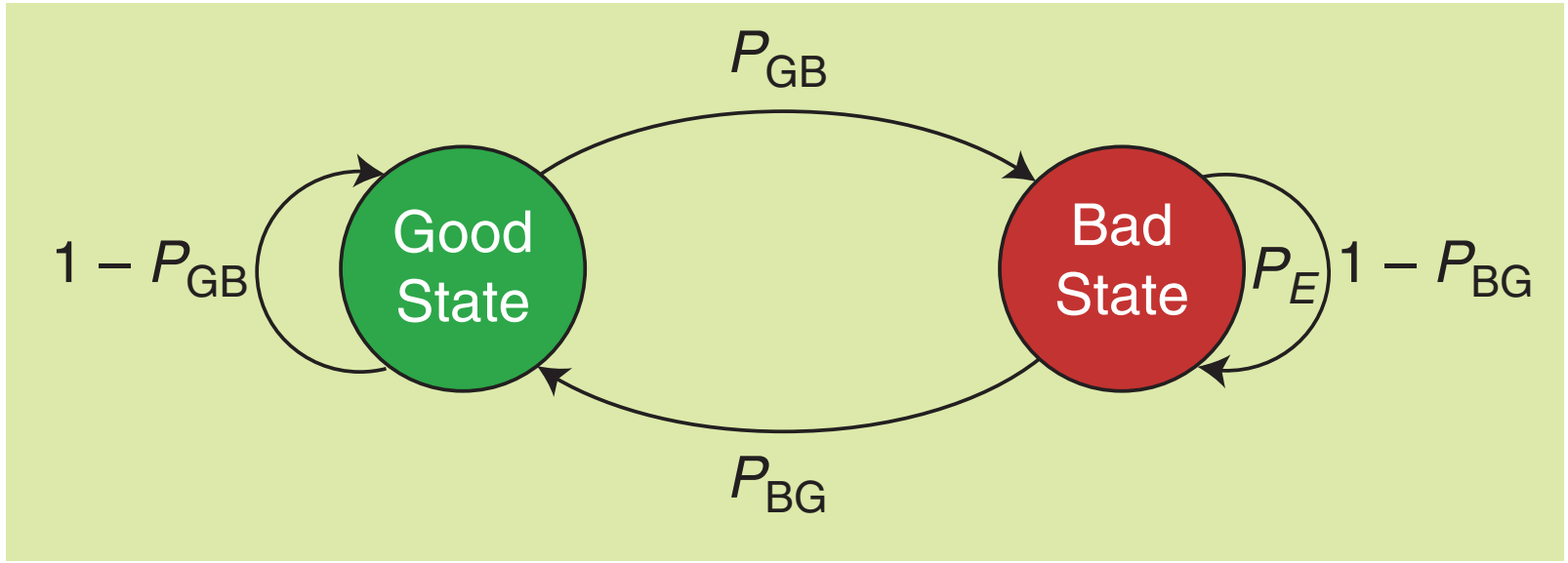


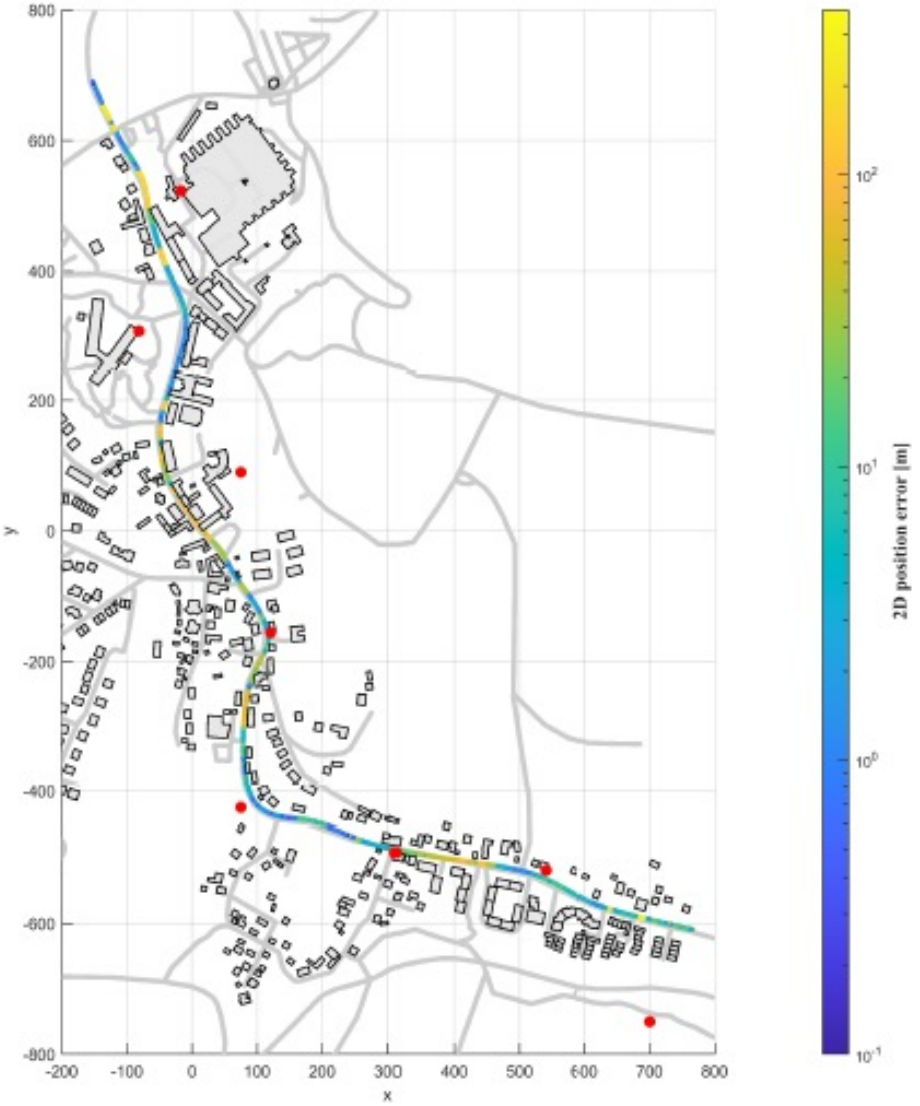
Figure 13: Number of correctly received BSM messages for vehicle 1

Behavioral Modelling for Intelligent InterSection



5G Vehicular Localization

- Positioning accuracy in Purkersdorf scenario
- Not a substitute for localization with GNSS, but enhances GNSS localization for poor satellite visibility

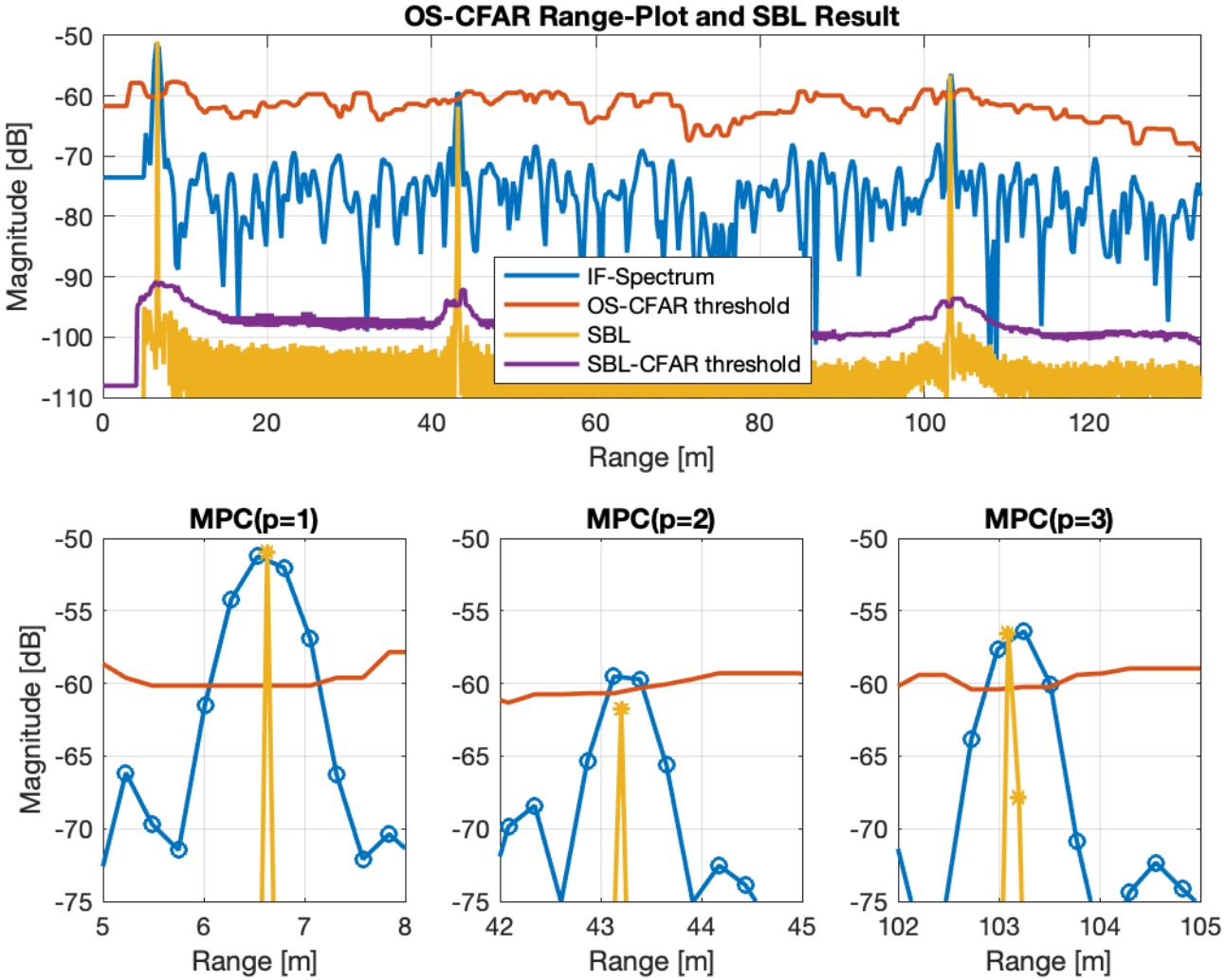


M. Ashury, C. F. Mecklenbräuker, J. Nausner: 5G-Positioning for Traffic Safety and Intelligent Intersections, 2023 17th Europ. Conf. Antennas and Propagation (EuCAP), Firenze, Italy, 26—31 March 2023. DOI: 10.23919/EuCAP57121.2023.10133434

Cooperative Perception

Vehicular FMCW Radar at 77 GHz

- FFT-based processing (blue)
- Sparse Bayesian Learning (yellow)
  - May use shared radar data from neighboring road users



M. Ashury, P. Gerstoft, C. F. Mecklenbräuker, D. Lungenschmied: Channel Estimation for FMCW Radar with Sparse Bayesian Learning, in Proc. 2023 IEEE Int. Conf. Antenna Measurements and Applications, Genoa, Italy,15—17 Nov 2023. DOI: 10.1109/CAMA57522.2023.10352684

Summary & Outlook

- **Basic Safety Messages keep adjacent road users informed of dynamic states and intentions**

- **5G offers Localization as a Service.**
  - **Not a substitute for GNSS localization, but**
  - **augments GNSS localization when satellite visibility of poor**

- **5G enables Cooperative Perception**
  - **by sharing of radar sensor data among adjacent road users**
  - **Extending road users' information horizon beyond line of sight**

- **IntIntSec is implementable with 5G IoT technology**

Project Team

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Q & A