V2X COMMUNICATION

DEVELOPMENT OF AN ITS-G5 ROAD SIDE UNIT FOR INTELLIGENT TRANSPORTATION SYSTEMS

Bastian Sander
Fraunhofer IFF

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Research Partners and Acknowledgement

Research Partners

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GALILEO-TRANSPORT Sachsen-Anhalt
Innovation Center für Digitale Infrastruktur, Mobilität und Logistik

THORSIS TECHNOLOGIES

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

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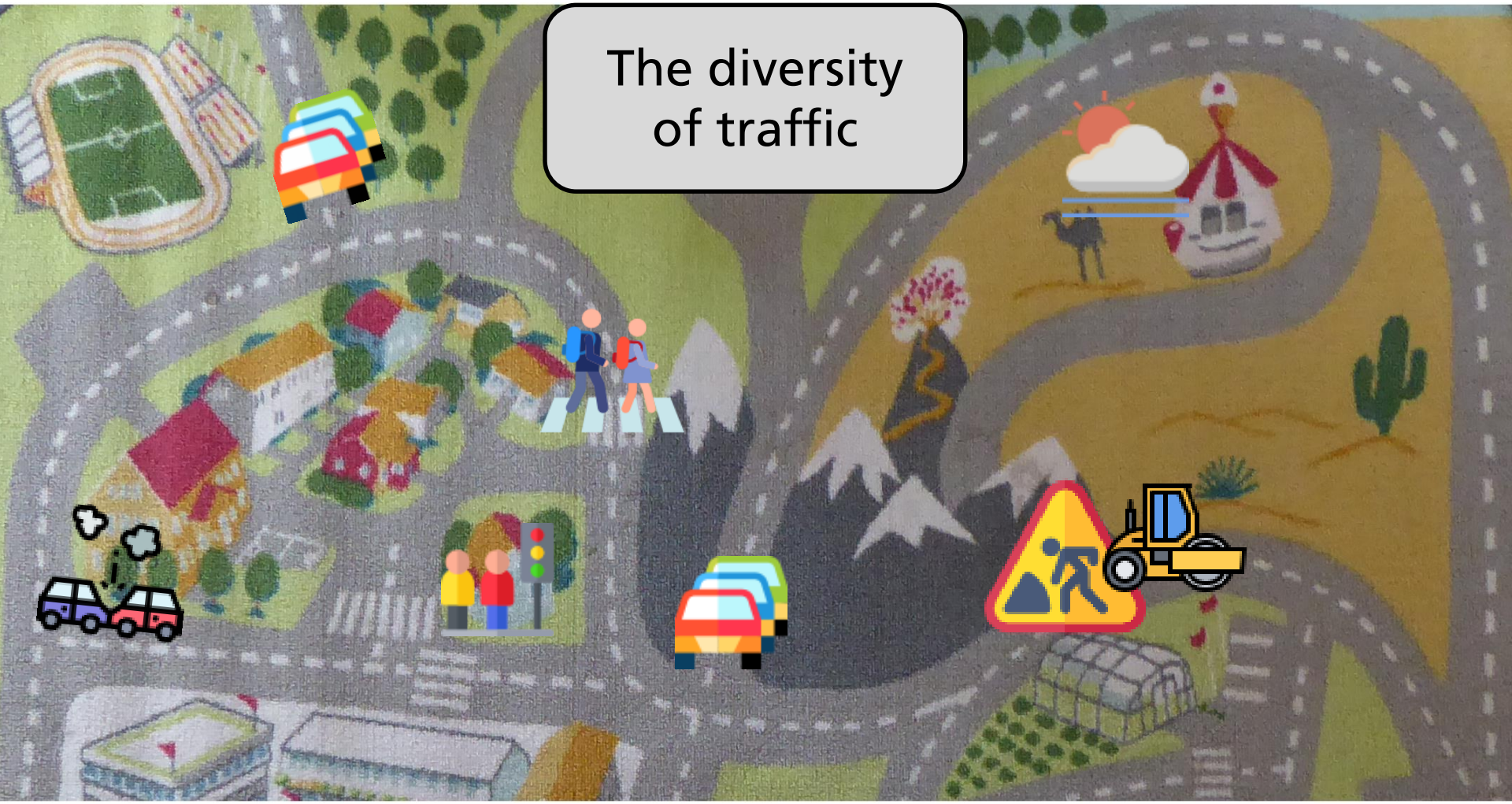
Outline

1. Intelligent Transportation Systems – a brief introduction
2. Our approach
   - Infrastructure
   - G5 modules and communication protocol stack
   - Test results
   - Live demonstration of RSU
3. Summary and conclusion
4. Future work

Intelligent Transportation Systems
In a nutshell



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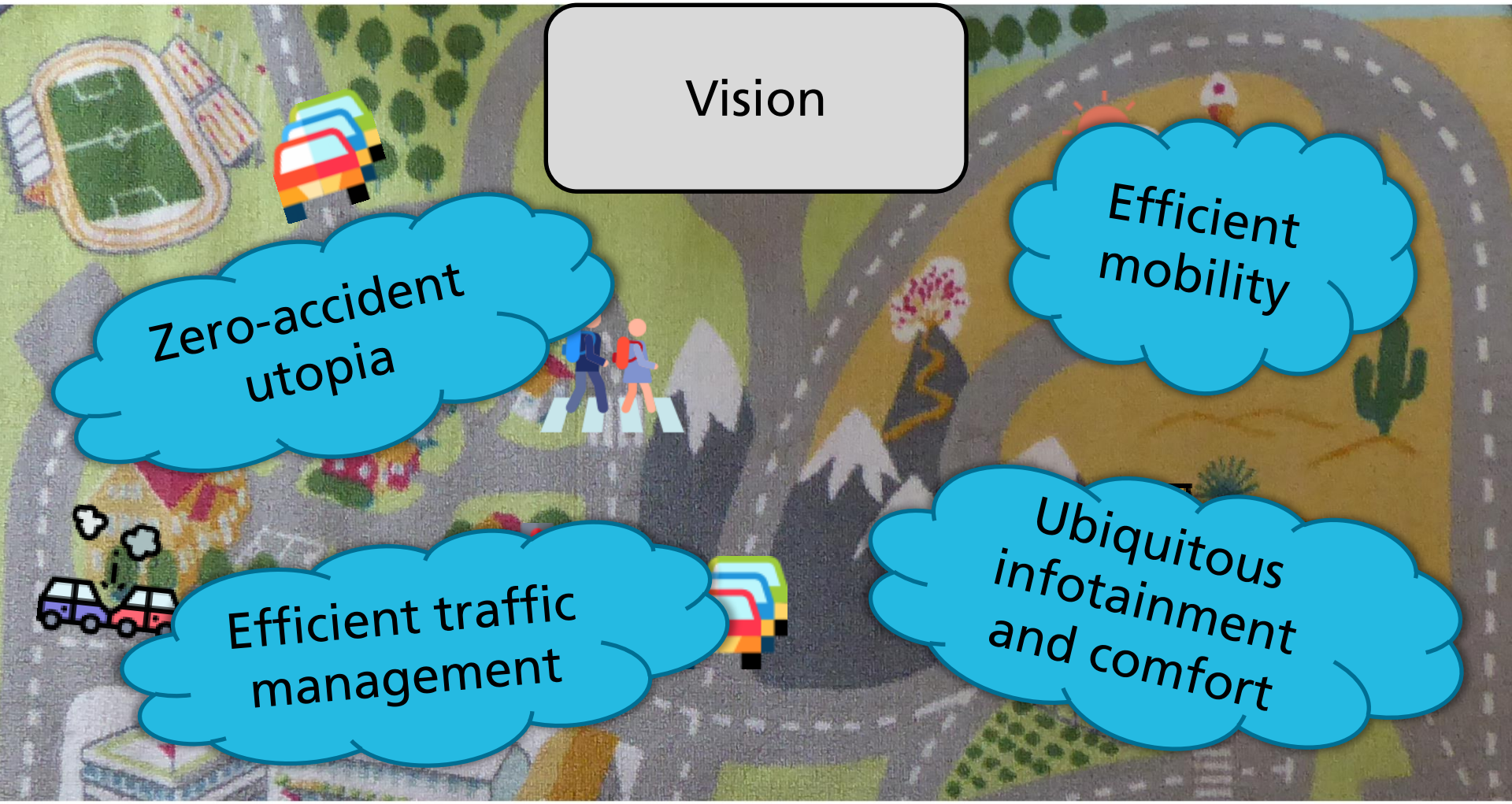

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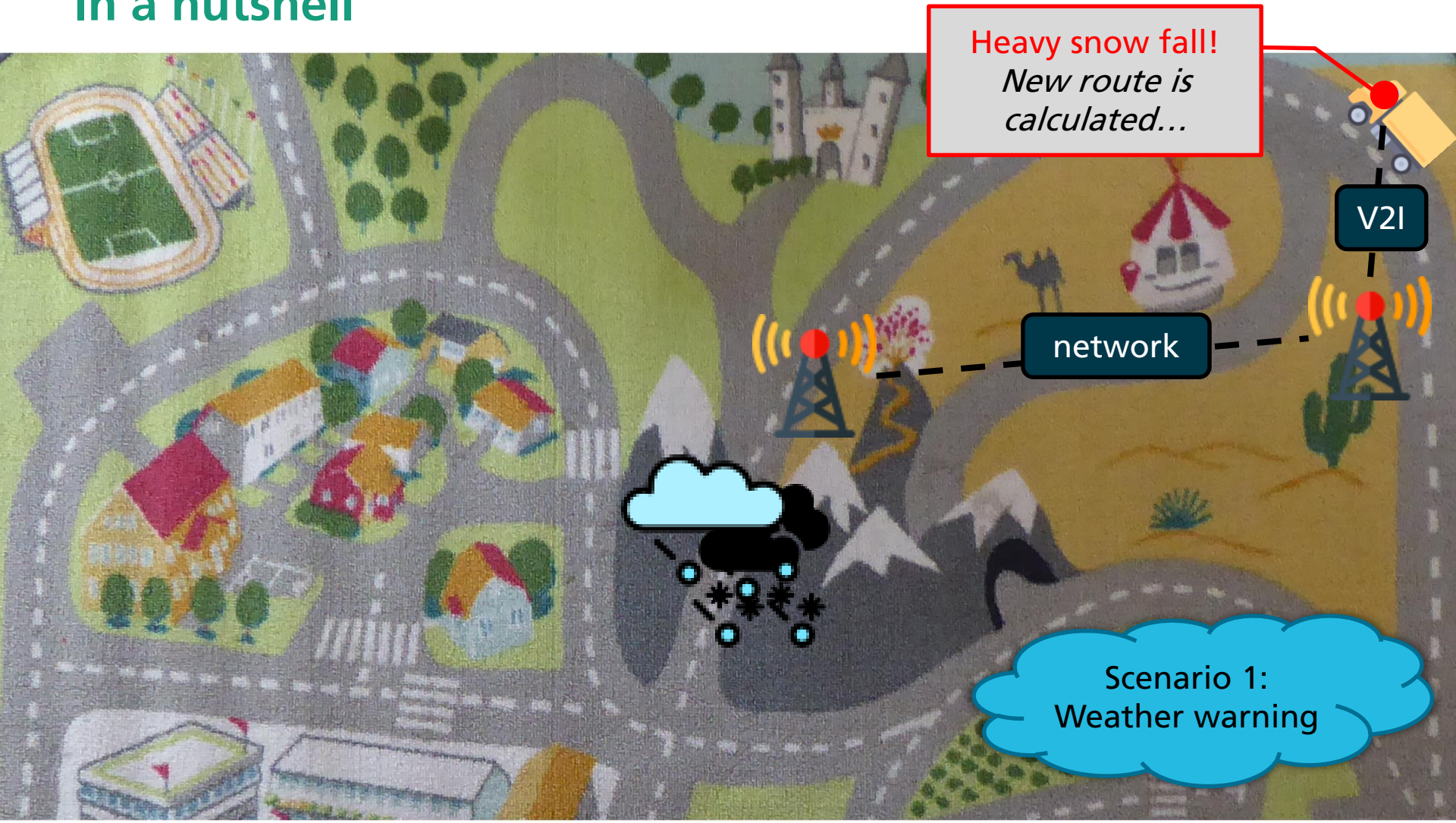

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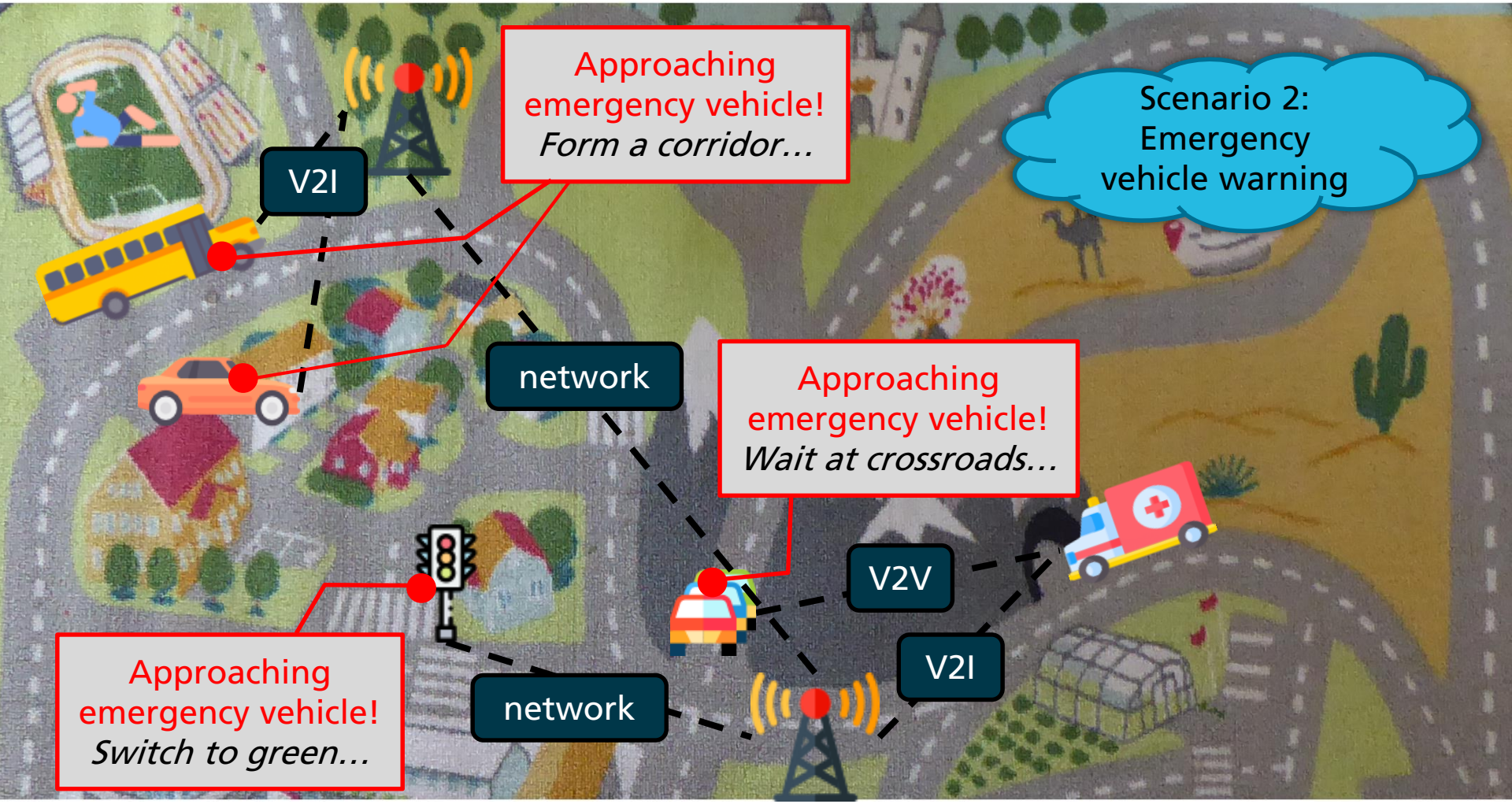

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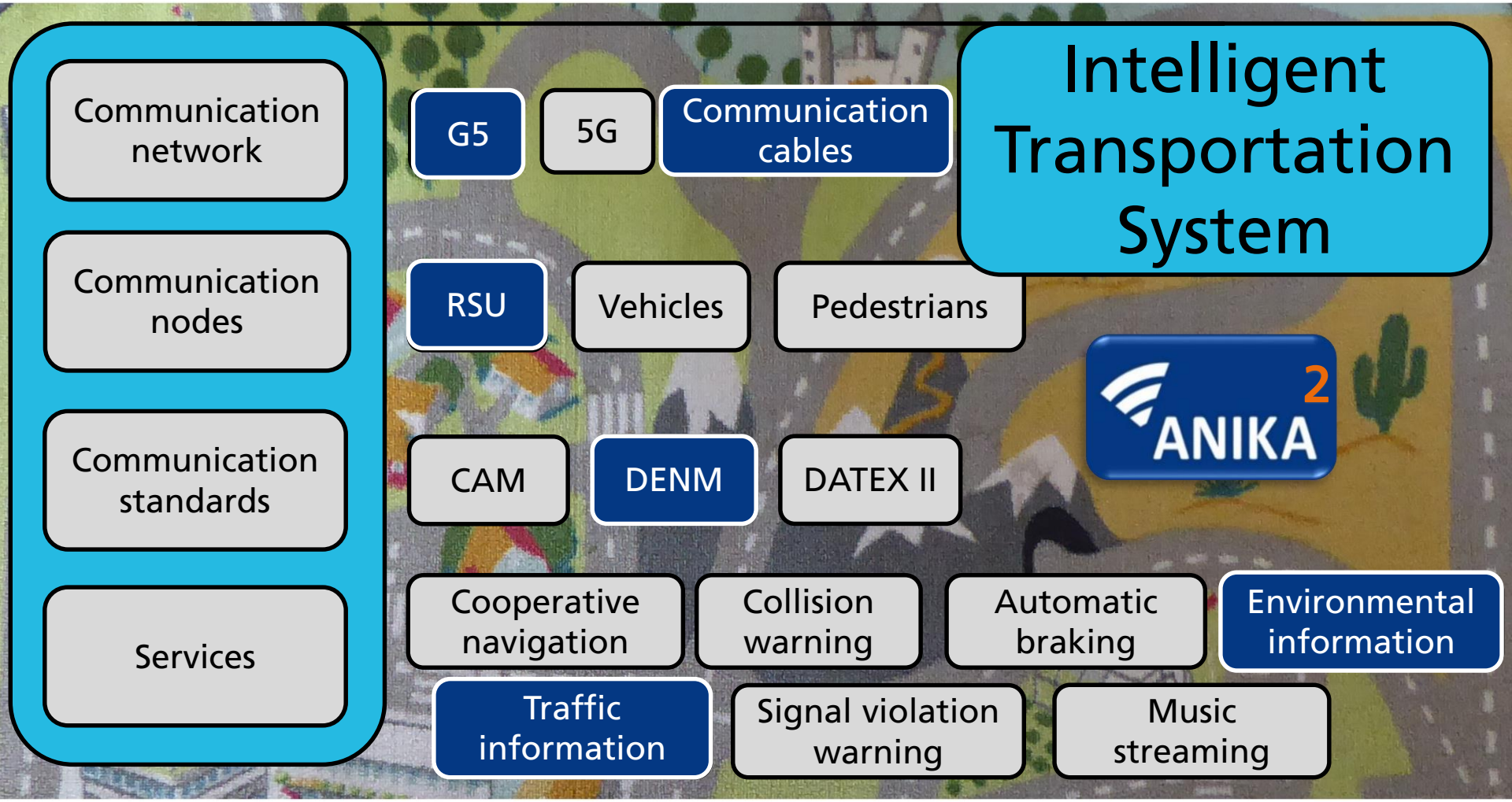

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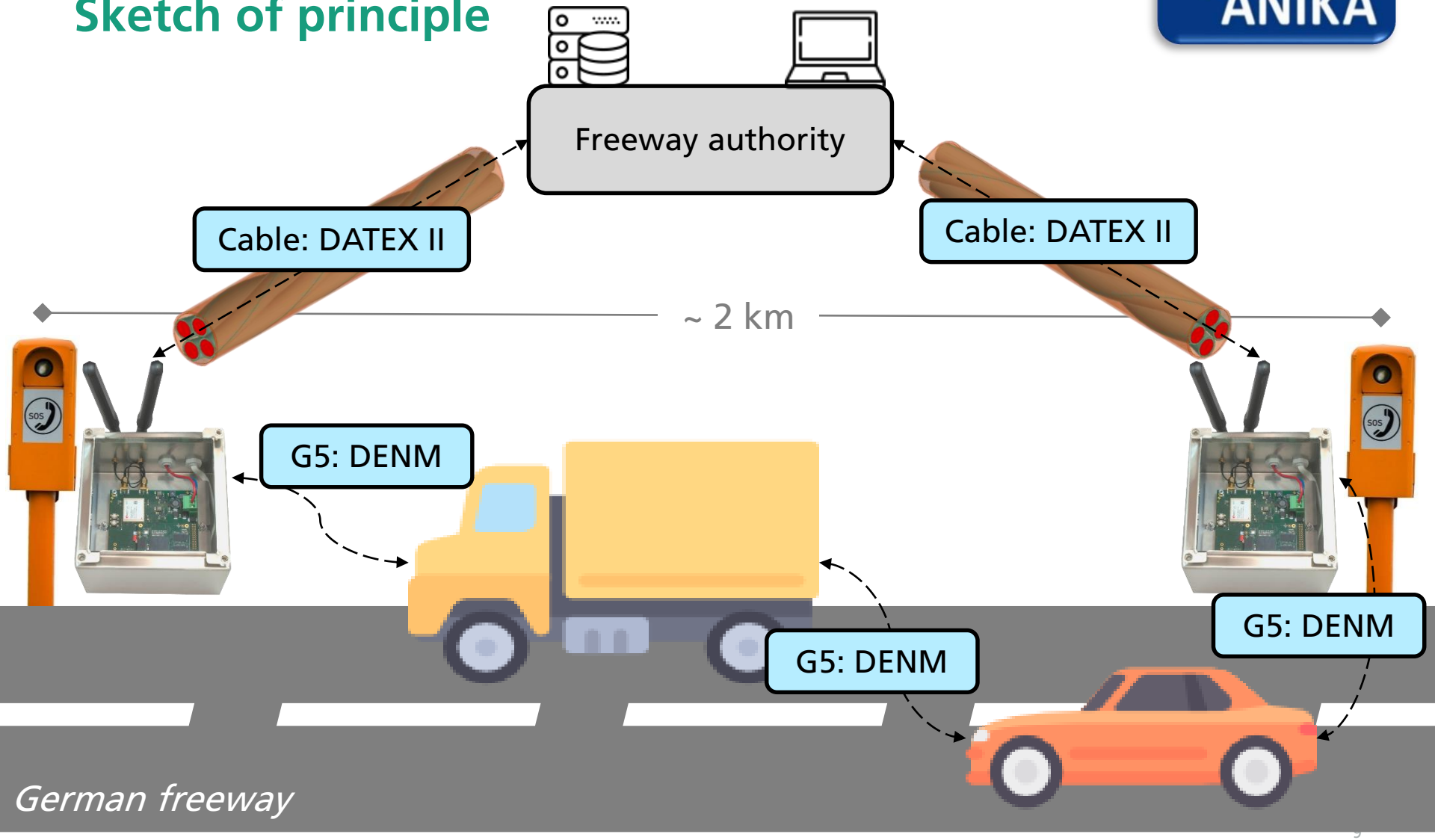
Intelligent Transportation System in ANIKA-2

Sketch of principle



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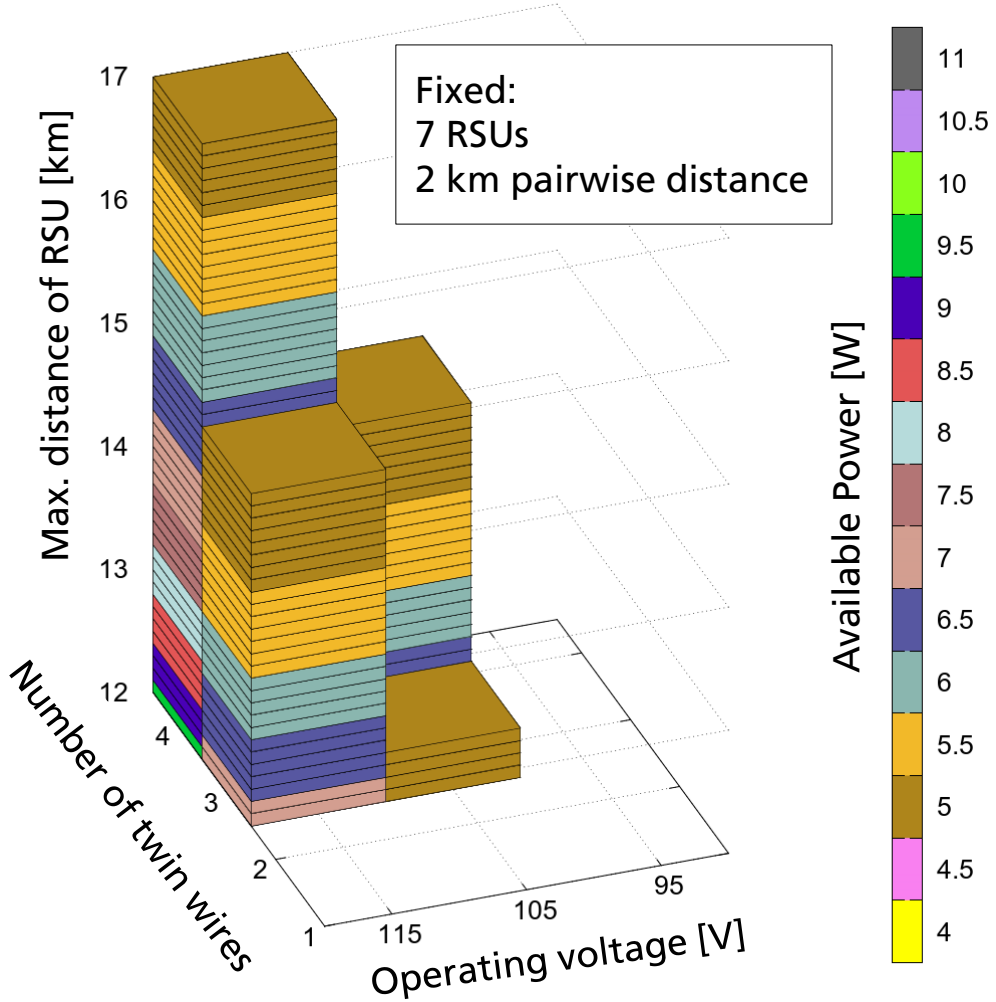
Developing the Road Side Unit
Feasibility study: Constraints on RSU

- Duration: 6 months in 2016
- Investigate stranded communication cable along freeway between Cologne and Bonn
- 60 twin wires, ~ 23 km length
- Verifications:
  - Measurements
  - Cable simulation
  - Network analysis
- Confirmed:
  - No crosstalk between twin wires
  - Sufficient energy supply of RSUs



Constraints on RSU:
≥ 3 twin wires for power supply
≤ 5 W of mean power input
≤ 8 W of peak power input

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Developing the Road Side Unit

RSU hardware

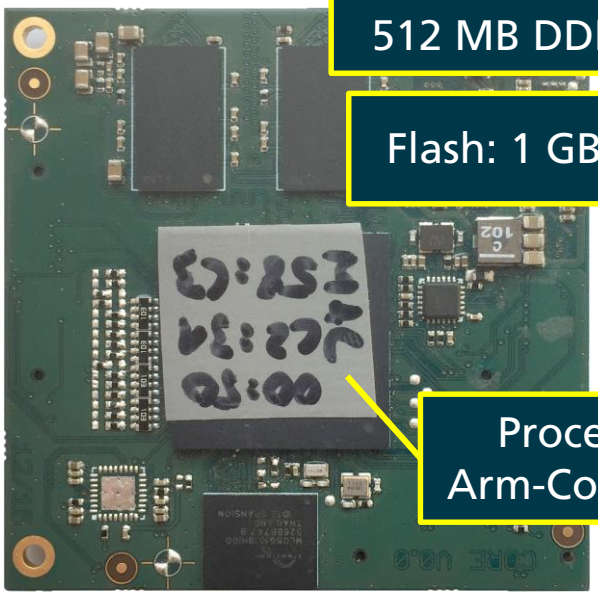
- Physical characteristics of ITS-G5 standard according to ETSI norm ES 202663

Core board

RAM:
512 MB DDR3

Flash: 1 GB

Processor:
Arm-Cortex-A9



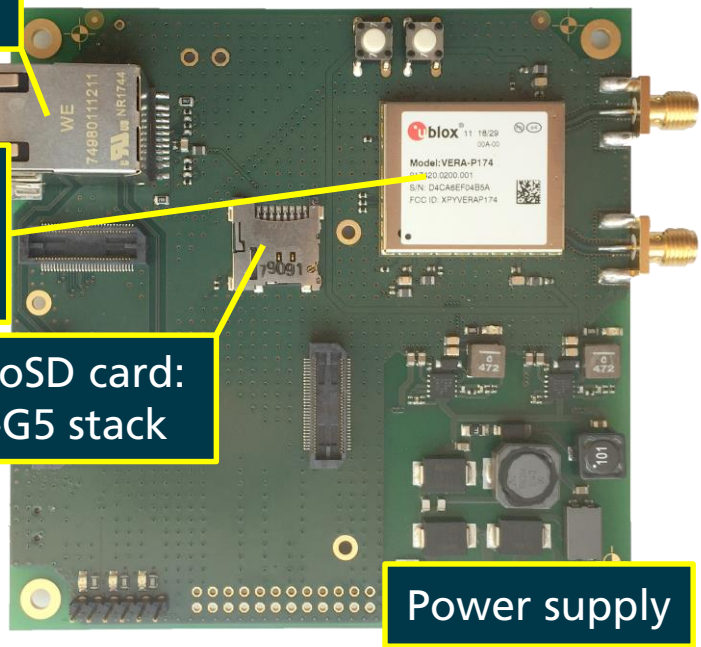
Slot for DSL,
Ethernet

Communication board

Vera-P174 transceiver
module: ITS-G5
functionalities

microSD card:
ITS-G5 stack

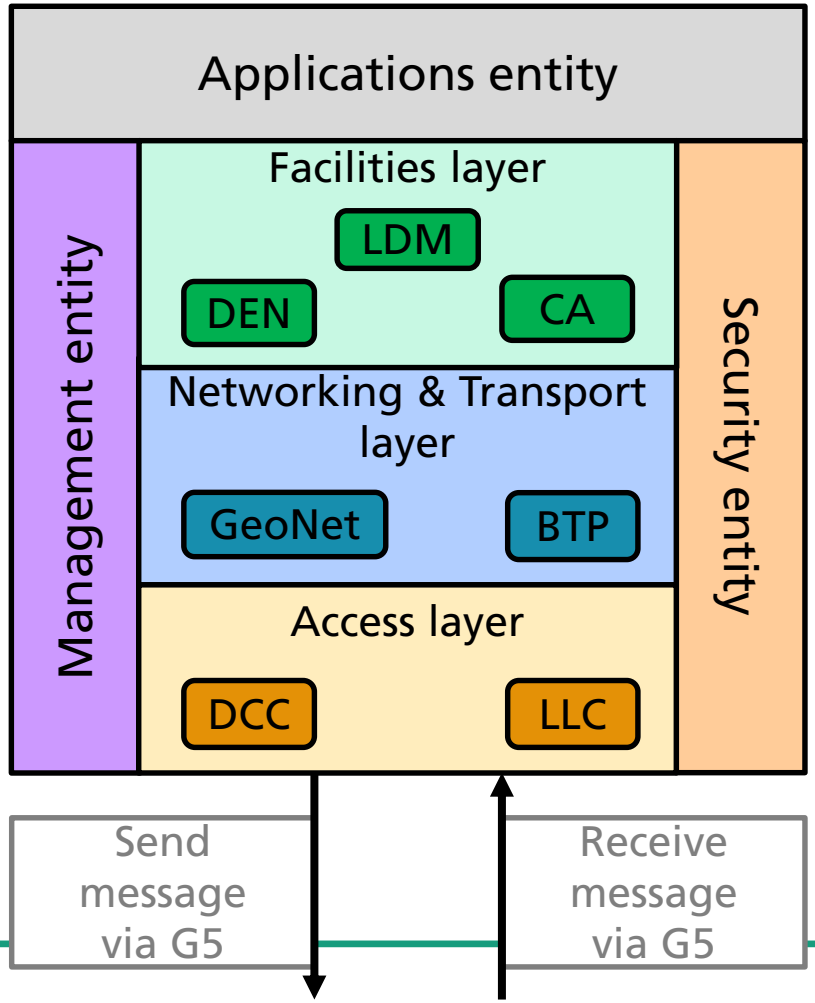
Power supply



Developing the Road Side Unit
RSU communication protocol stack

- Communication reference architecture according to ETSI norm EN 302665

Stack latency < 0.5 ms

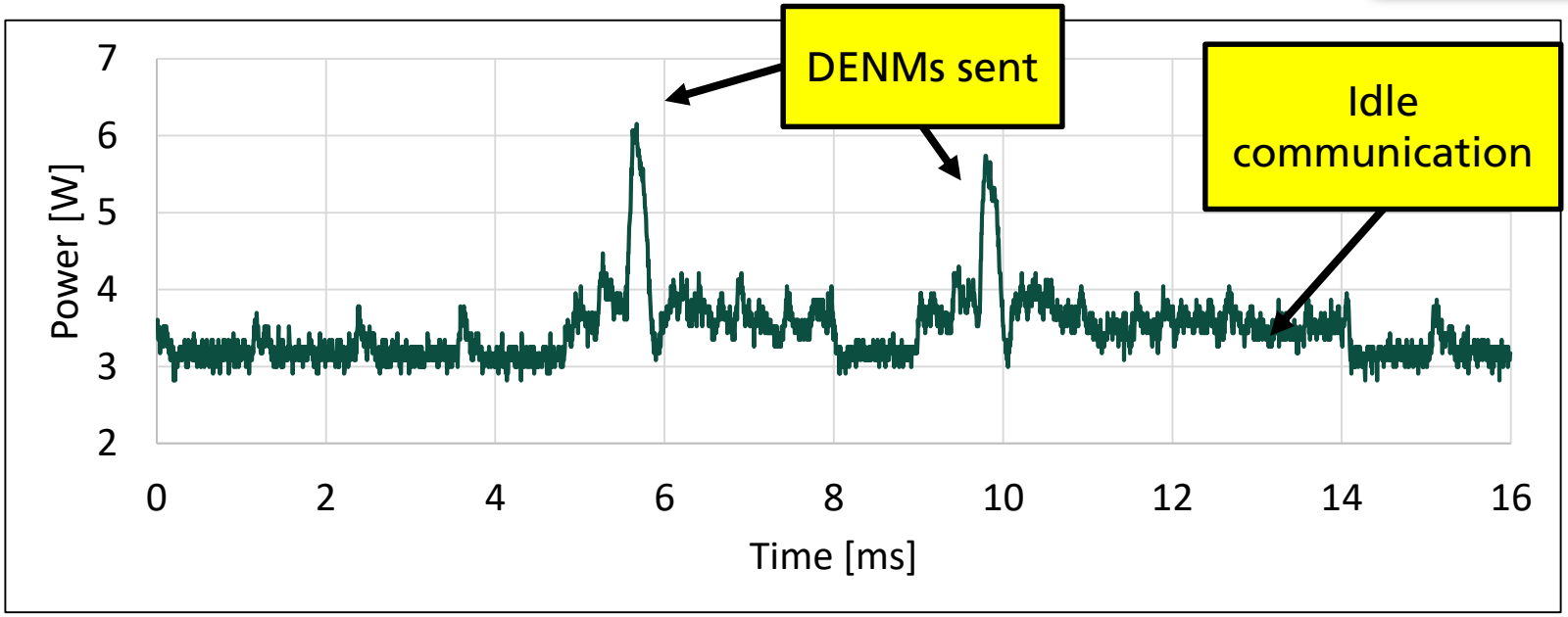


- Generates and sends DENMs or periodic CAMs from trigger
- Adds header of GeoNet/BTP
- Restricts sending based on channel business and message priority
- API to VERA-P1 transceiver module

- Collects DENMs and CAMs
- Decoding, forward to LDM
- Decodes GeoNet/BTP header, forwards to DEN or CA service
- Decodes MAC header and LLC header
- API to VERA-P1 transceiver module

Developing the Road Side Unit

Test on power consumption



- Power consumption measured by an oscilloscope
- DENMs are sent through one channel (channel G5CC) with rate 6 Mbit/s
- Center frequency 5.9 GHz, bandwidth 10 MHz
- Size of DENM: 323 Bytes (4 Byte Field Checksum + 78 Byte Header + 241 Byte DENM)
- Mean input power: 3.5 W
- Peak input power: 6.2 W

Values are in line with threshold from feasibility study

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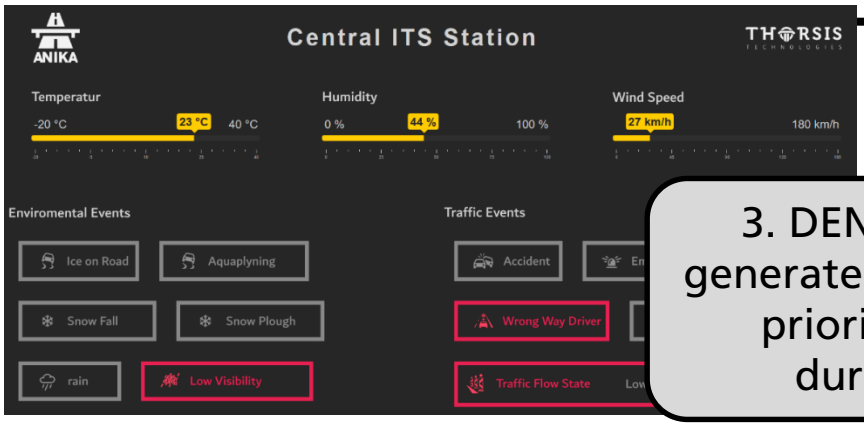
Developing the Road Side Unit
Road tests on sending range

All tests: clear weather, partially with shadowing of line-of-sight

Developing the Road Side Unit

Live demonstration of RSU

User interface represents freeway authority

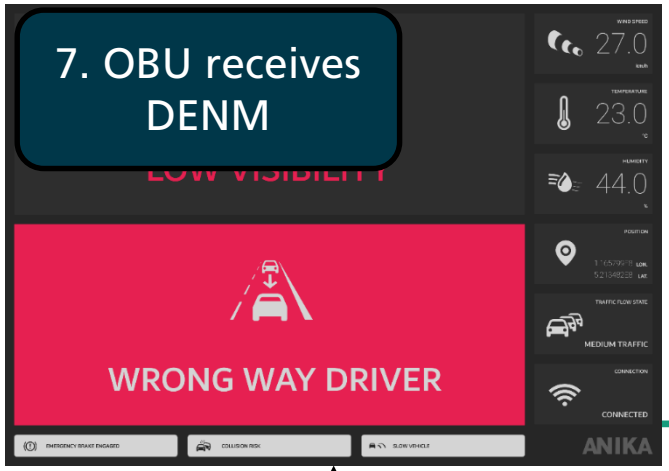


1. Sends HTTP request

2. App interprets request

3. DENM trigger is generated incl. message priority, sending duration etc.

User interface represents receiving vehicle



Applications entity

4. DENM is generated

5. DENM is broadcasted based on priority

Management entity

Facilities layer

Networking & Transport layer

Access layer

Security entity

network

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Developing the Road Side Unit
Summary and conclusion

Feature of ITS	Stage of development
Sufficient power supply of RSU by stranded comm. cable	Confirmed: 5 W with 7 RSUs
No crosstalk with parallel services in comm. cable	Confirmed
Consumption power test	≤ 4 W of mean power input ≤ 7 W of peak power input
Sending range	~ 600 m at clear weather with direct line-of-sight
ETSI[1] norms	Fullfilled

Conclusion:
Hardware + software stack are completely functional to realize an ITS-G5 RSU for V2X applications.

[1]European Telecommunications Standards Institute

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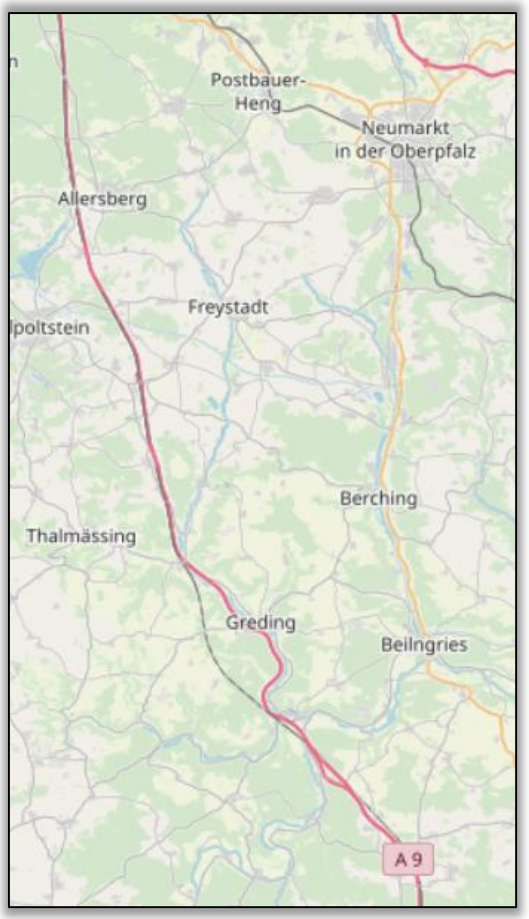
Developing the Road Side Unit
Next steps (partly beyond ANIKA-2)

- Tests on sending range:
  - maximum sending range in line-of-sight
  - under bad weather conditions
- Tests on a real freeway (2nd half in 2019)
  - Virtual testbed of BMVI[1] on A9 in Bavaria
  - Section between Göggelsbuch and Greding (22 km length)
- More functionalities to be implemented in the stack:
  - Security management
  - Multi-hopping (vehicle-to-vehicle communication)
  - Channel switching
  - DATEX II format of messages in mutual communication between infrastructure (RSUs, freeway authority)



[1]Federal Ministry of Transport and Digital Infrastructure

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Thanks for the attention you spent on V2X communication!

Univ.-Prof. Dr.-Ing. Michael Schenk