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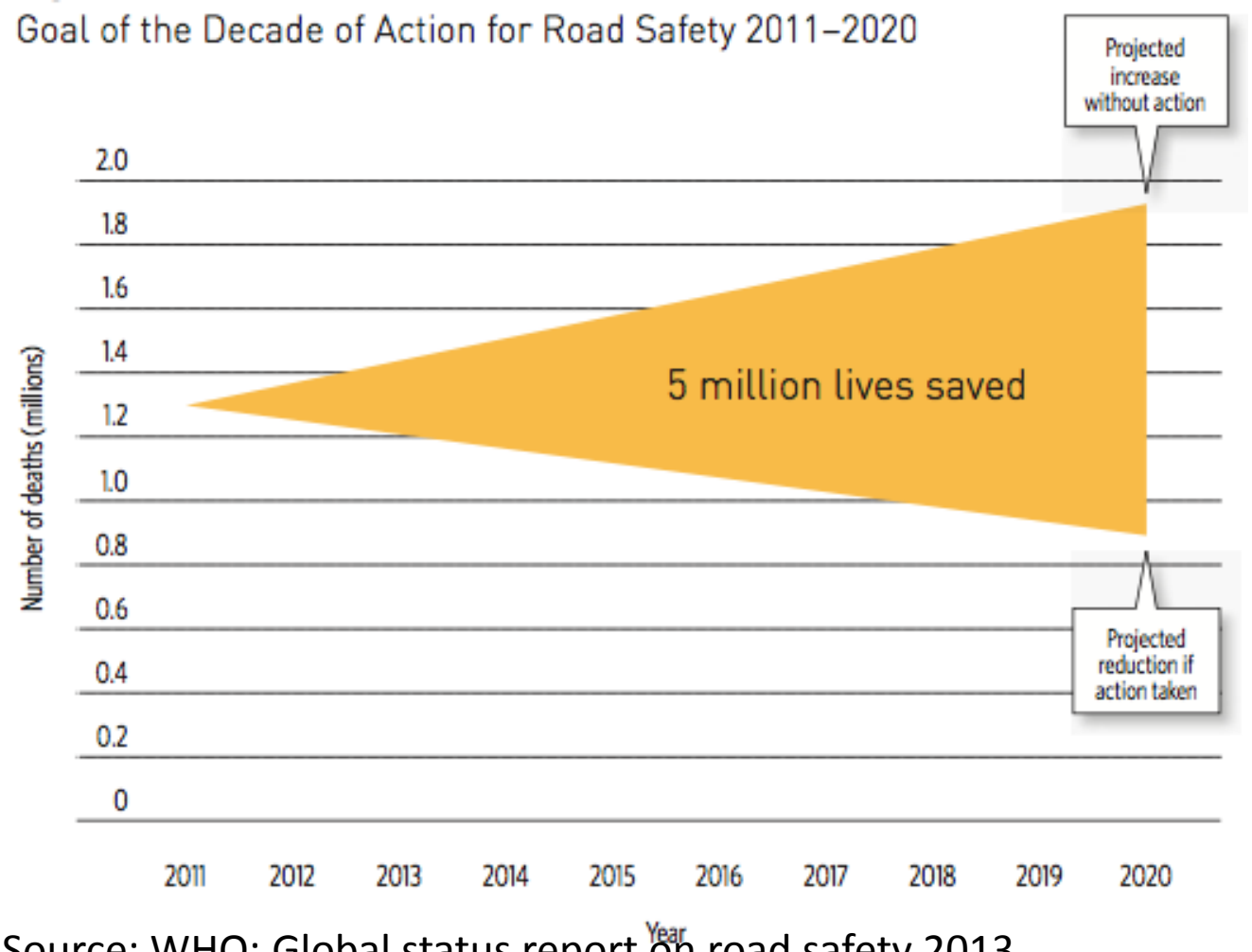
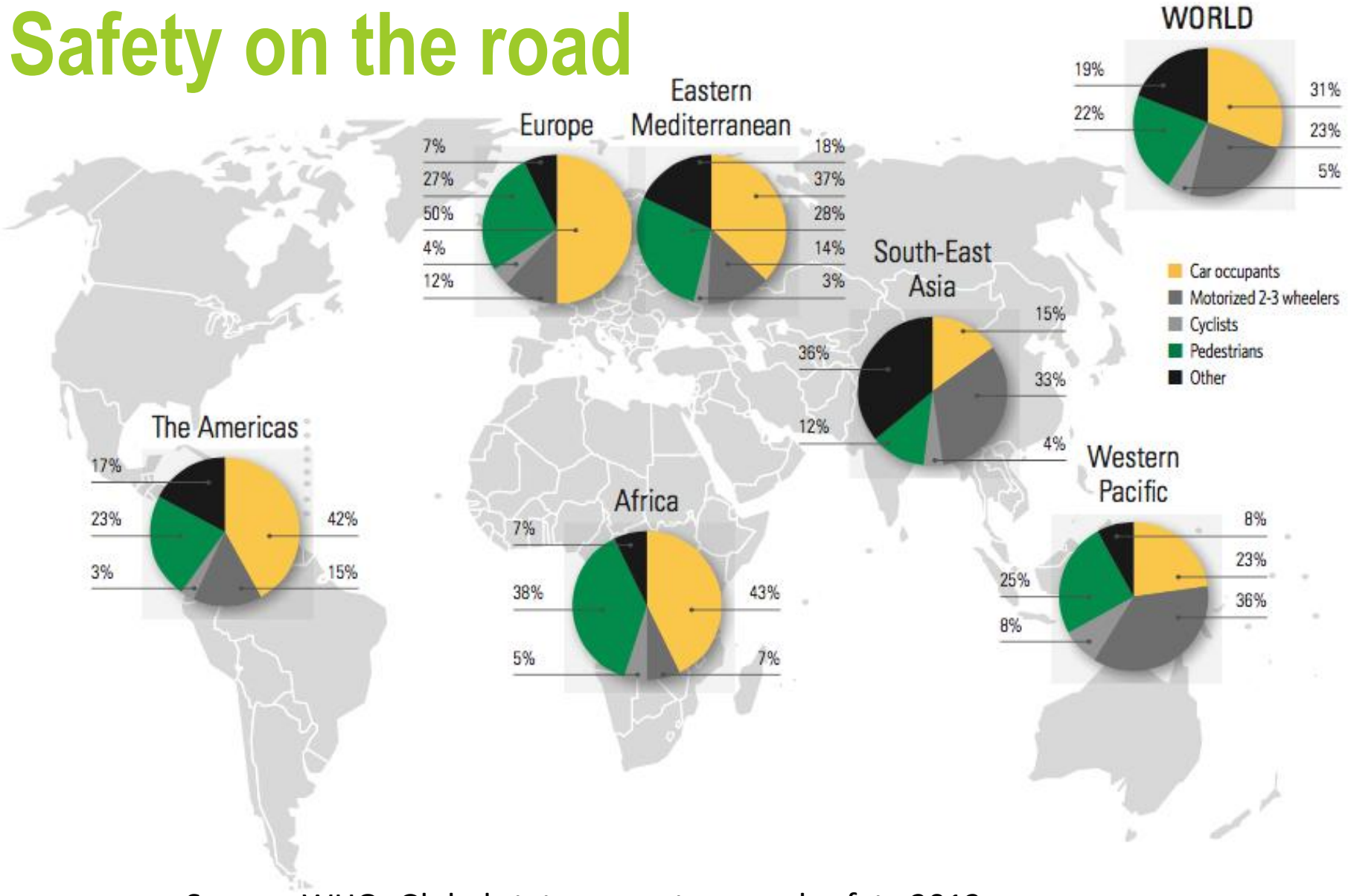
Information exchange aspects of autonomous driving

Safety on the road



Source: WHO: Global status report on road safety 2013

Safety on the road



Source: WHO: Global status report on road safety 2013

Safety on the road

WHO: Decade of Action road safety program

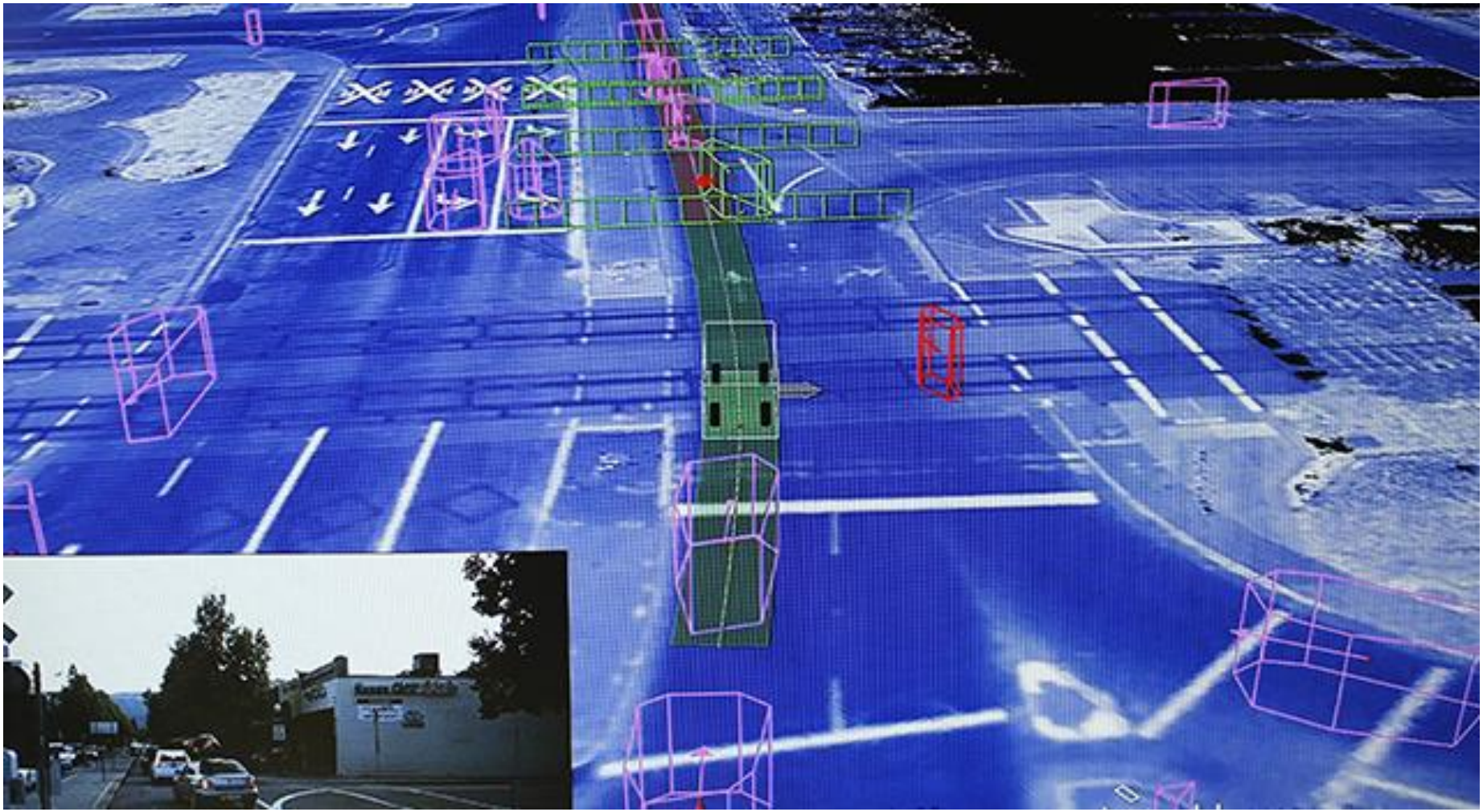
Source: WHO: Global status report on road safety 2013

Safer roads, mobility, vehicles? How?

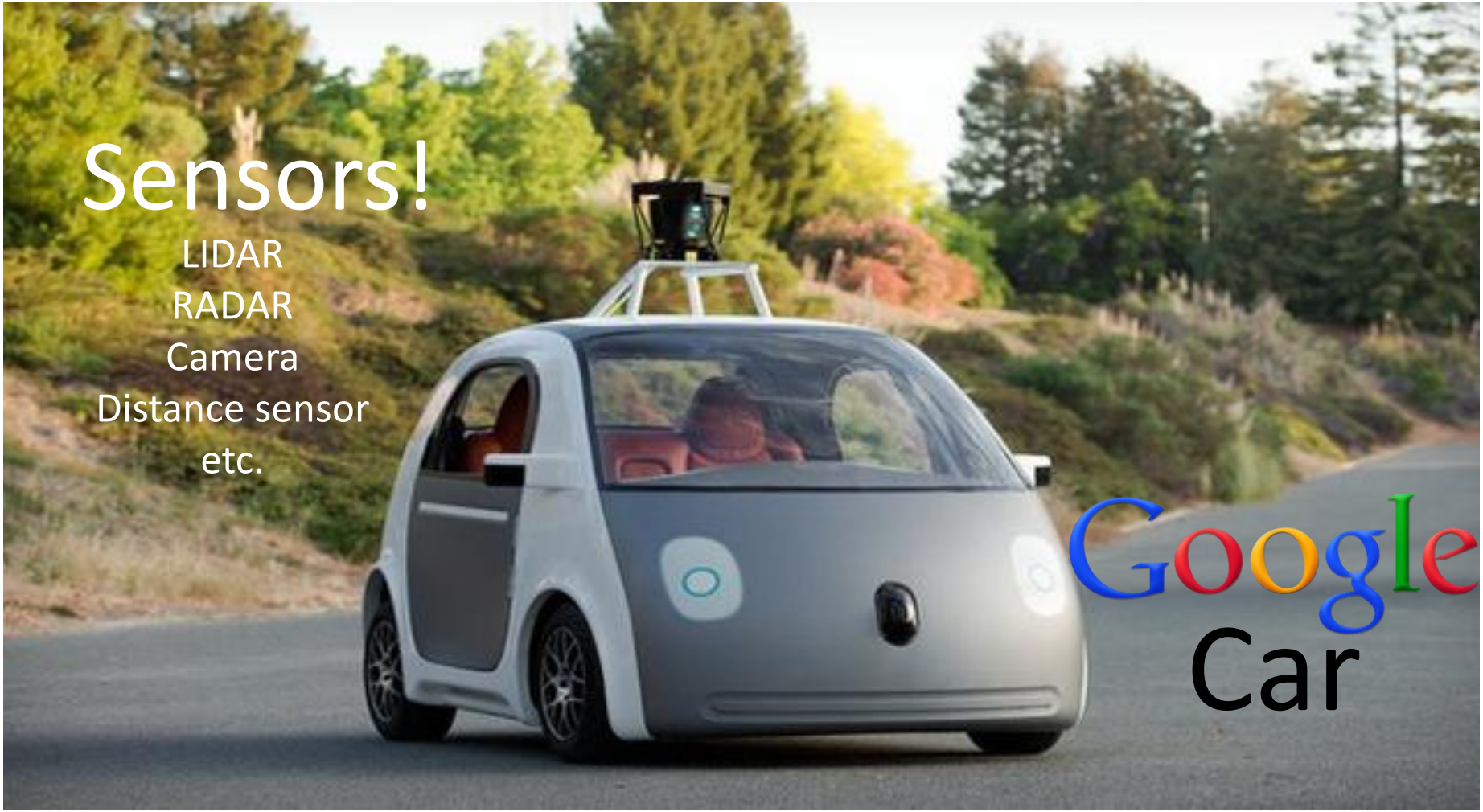
Minimize the human-factor!

Autonomous driving!

Autonomous driving?

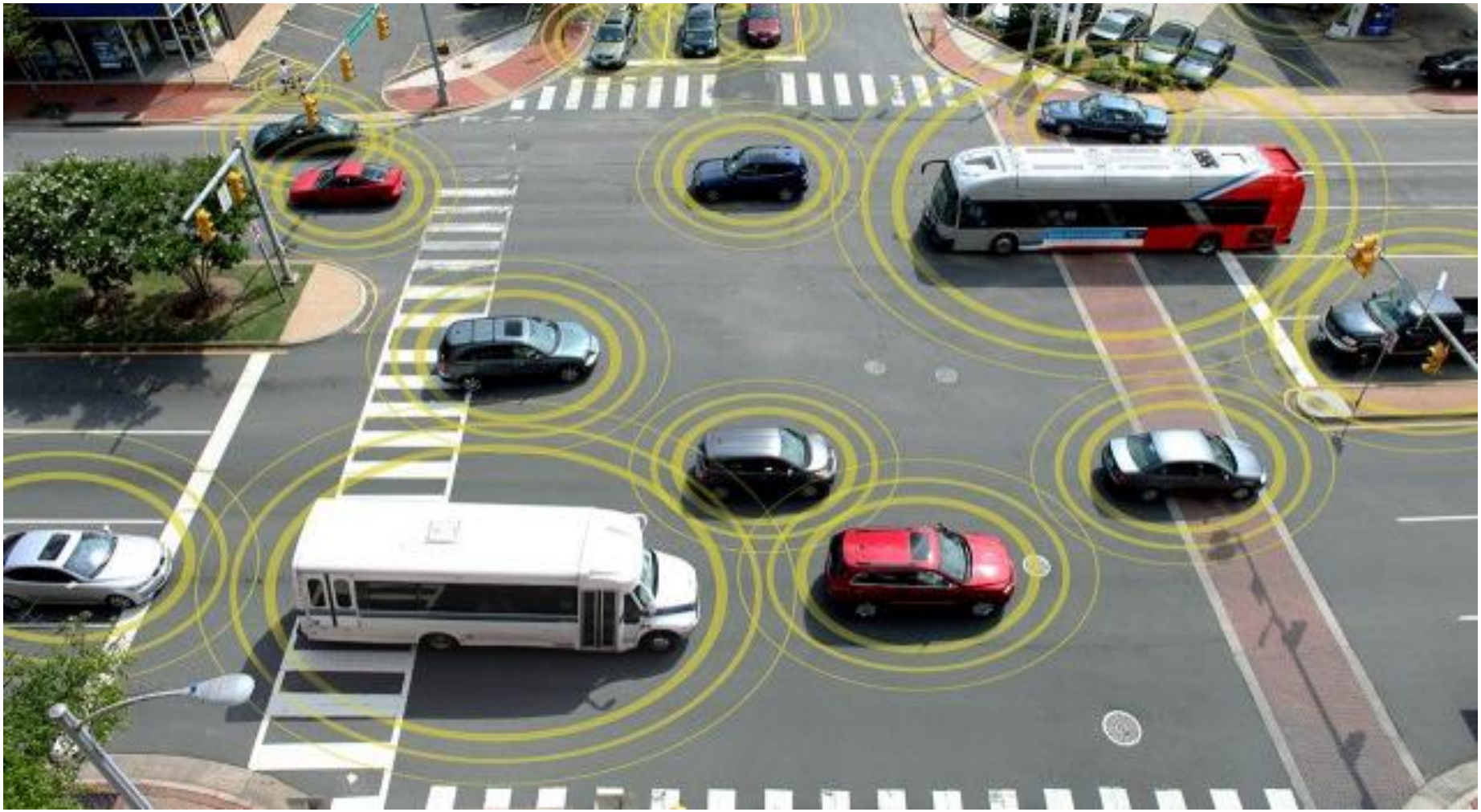


Autonomous driving? How?



Autonomous driving? How?

Vehicle-to-vehicle communication



Introduction of V2X

- Vehicle-to-vehicle (V2V) communication
- Vehicle-to-infrastructure (V2I) communication

- Continuous information exchange, including all vehicle-related information and details of relevant events

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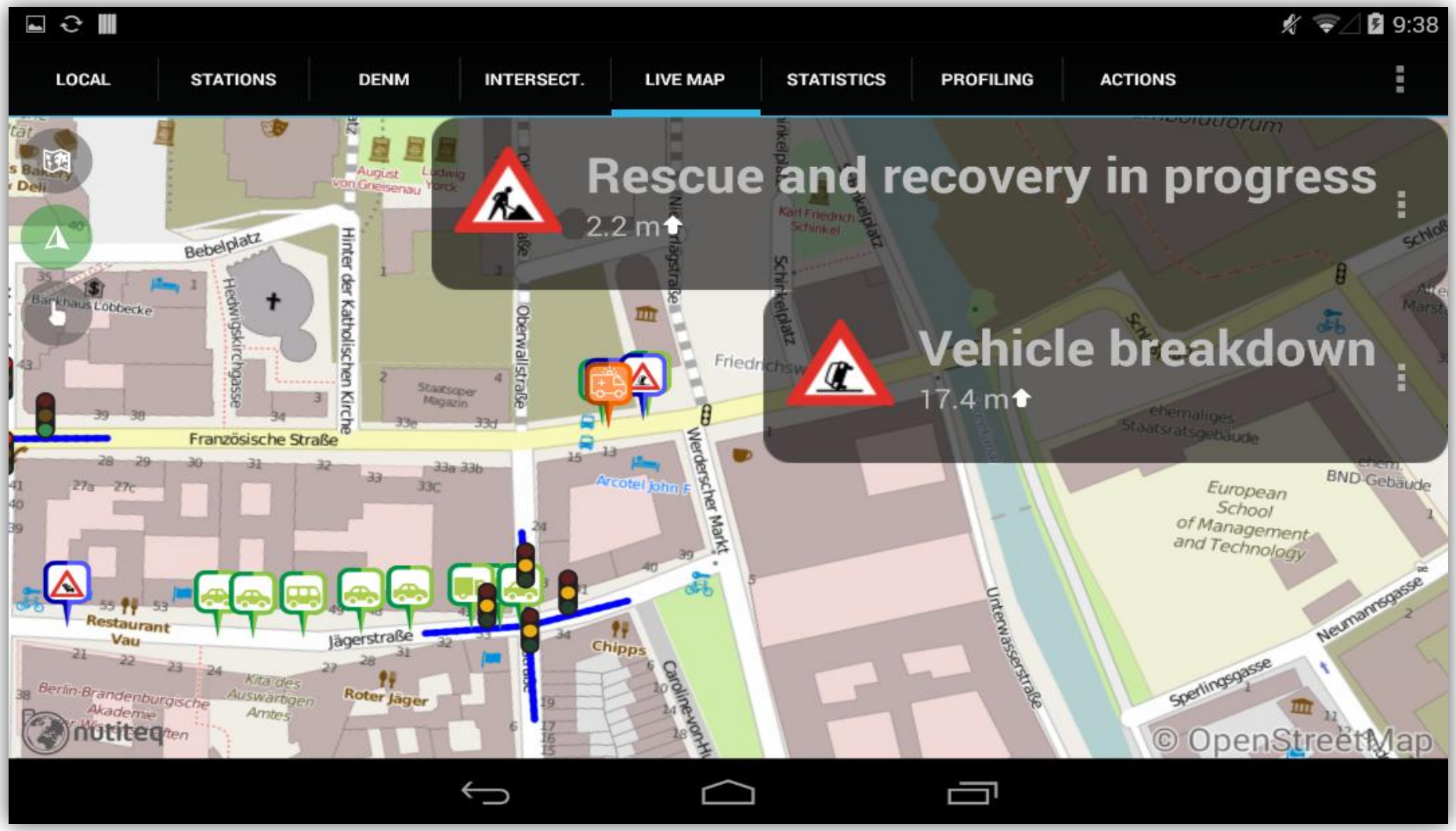
Local Dynamic Map



Local Dynamic Map

Collect

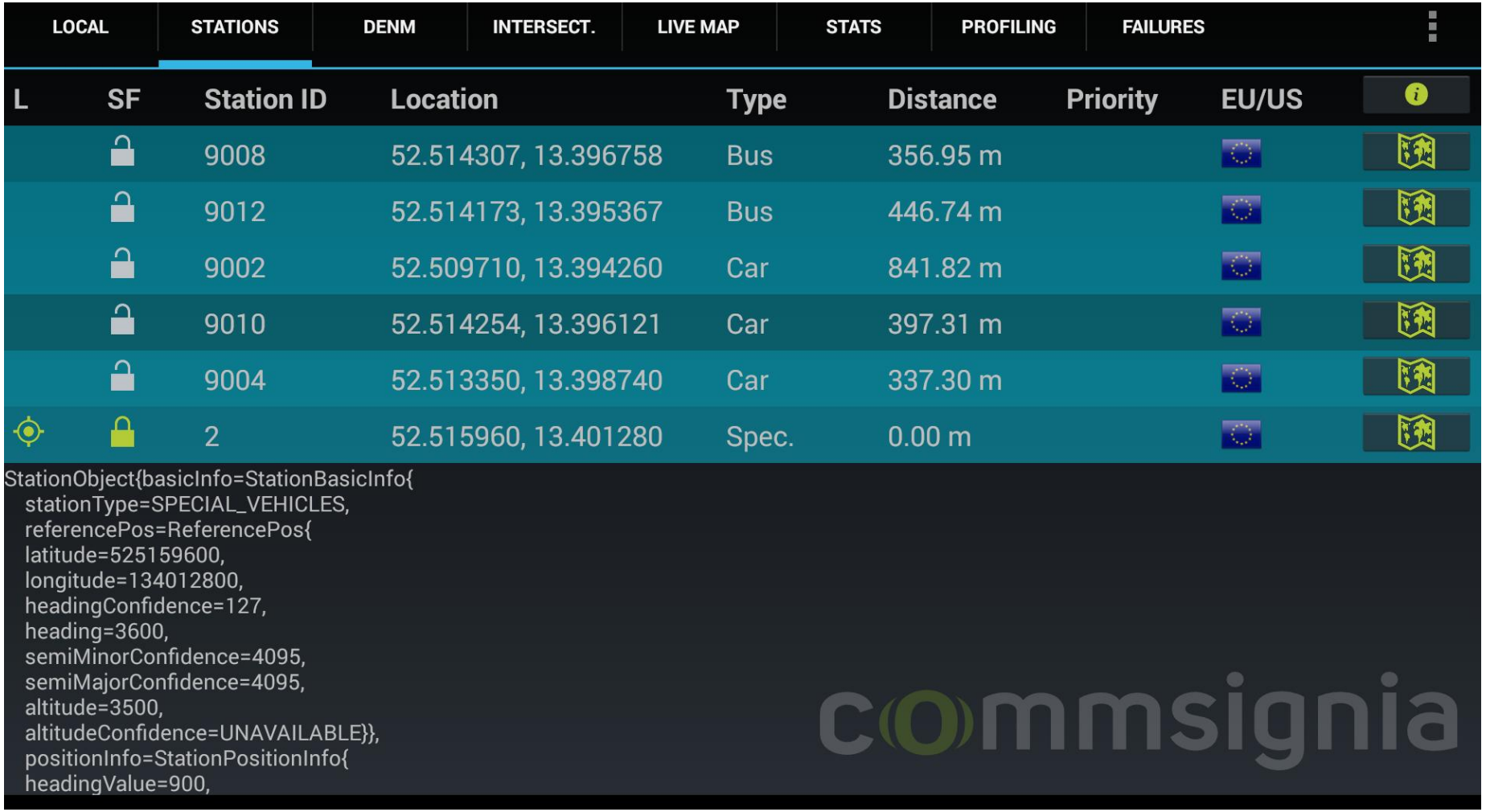
Store

Aggregate

Filter

Manage (e.g. expiration)

ETSI CAM, IEEE BSM



ETSI CAM, IEEE BSM

Position (latitude, longitude, lane number, etc.)

Movement (speed, heading, acceleration, etc.)

Control (throttle, brake, etc.)

Miscellaneous (e.g. exterior lights)

Light bar and siren in use

Priority request

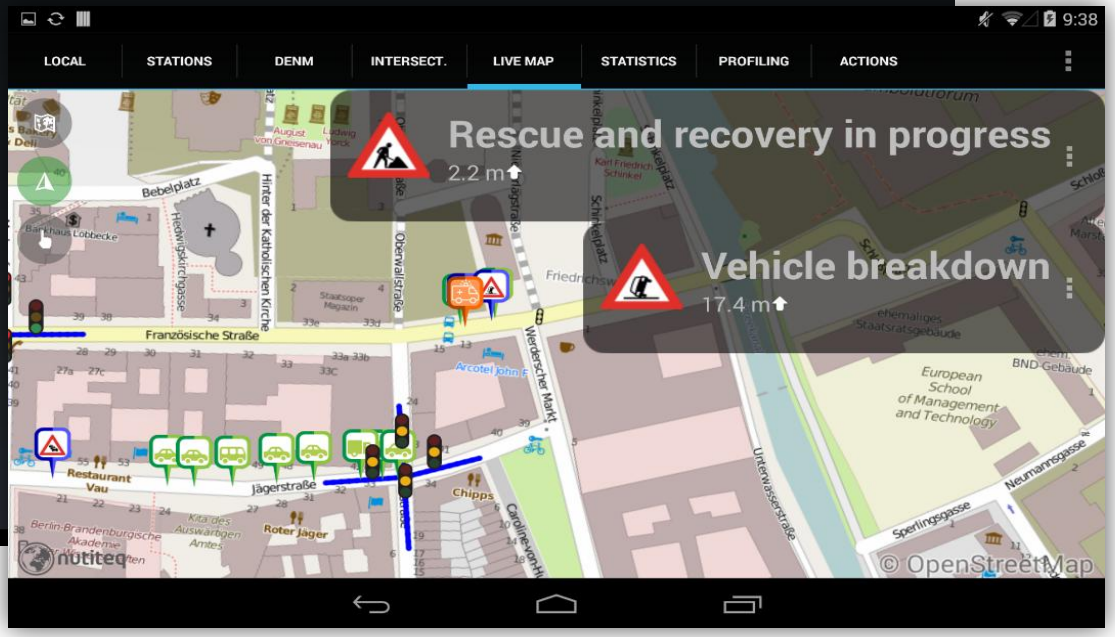
Special information (e.g. closed lanes)

ETSI DENM

LOCAL | STATIONS | DENM | INTERSECT. | LIVE MAP | STATS | PROFILING | FAILURES

SF	ID	Location	Cause	Sub Cause	Termination	Validity d
🔓	1.3	52.515280, 13.397150	RESCUE_AND_RECOVERY_WORK_IN_PROGRESS	1		80 s
🔓	1.0	52.514107, 13.393679	TRAFFIC_CONDITION	6		80 s
🔓	1.2	52.513096, 13.404240	ROADWORKS	5		80 s

```
DENM{actionID=DENMActionID{stationID=1, sequenceNumber=2},
  detectionTime=Thu Jan 01 01:10:54 CET 2004,
  referenceTime=Thu Jan 01 01:10:54 CET 2004,
  isNegation=false,
  isCancellation=false,
  eventPosition=ReferencePos{
  latitude=525130960,
  longitude=134042400,
  headingConfidence=127,
  heading=3600,
  semiMinorConfidence=4095,
  semiMajorConfidence=4095,
  altitude=800001,
  altitudeConfidence=UNAVAILABLE},
  relevanceDistance=LESS_THAN_1000M,
  relevanceTrafficDirection=ALL_TRAFFIC_DIRECTIONS,
  validityDuration=80,
  transmissionInterval=1000,
  stationType=null,
  informationQuality=0
```



ETSI DENM

Event position

Timing (detection, validity)

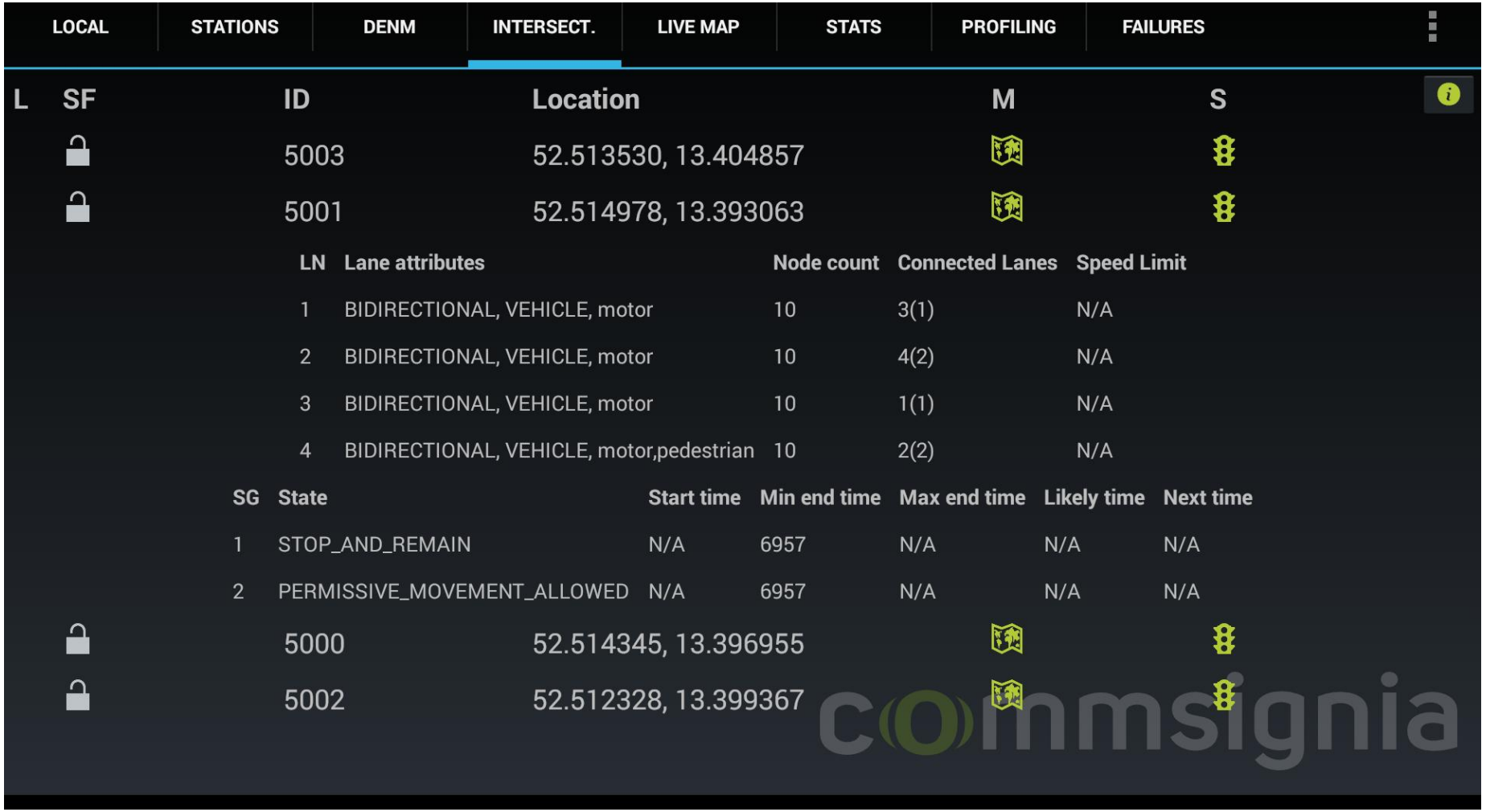
Event type

Linked events

Recommended itinerary

Other facilities

MAP and SPAT



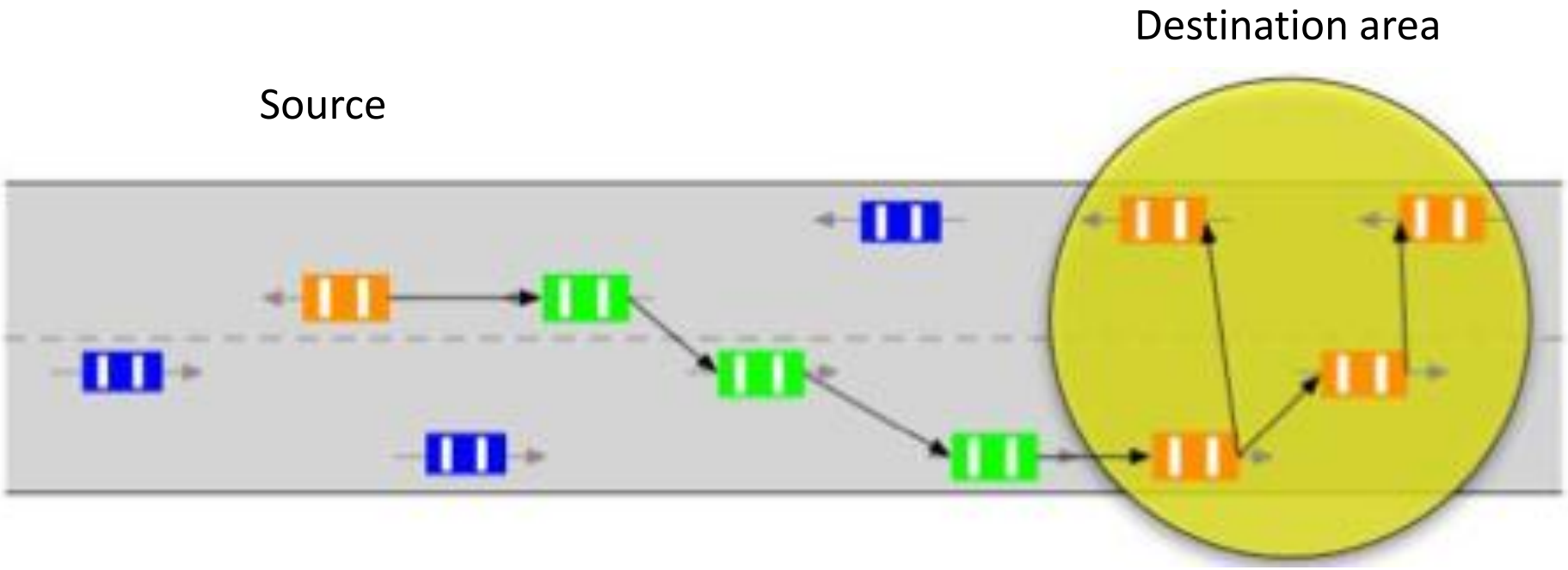
Other facilities

- SRM/SSM: Signal Request/Status Message
- IVI: In-vehicle Information
- PVD: Probe-vehicle Data
- Road Tolling Messages
- Service Advertisement

GeoNetworking

- ETSI V2X network protocol
- Geo-dissemination
- Common protocol types:
  - Single-hop broadcast
  - Topologically-scoped broadcast (a.k.a. N-hop broadcast)
- GeoBroadcast!
- Transport protocol: BTP

GeoBroadcast



IEEE WSMP 

- Simple network & transport protocol
- Minimal header frame
- Widely applied in the US

IEEE 802.11p (WAVE) = ETSI G5 = ISO CALM M5

5840-5910 MHz

Different channels for different applications

Control channel 5,9 GHz

Ad-hoc

Same MAC and LLC format as common IEEE802.11x

Security

Sign - verify

Elliptic-curve cryptography

Validity restrictions (time, region, application)

Key exchange

Encrypted messages

Summary of V2X

Shortest possible packet size

Fastest possible message dissemination

Priority for safety communication

Real-time information exchange

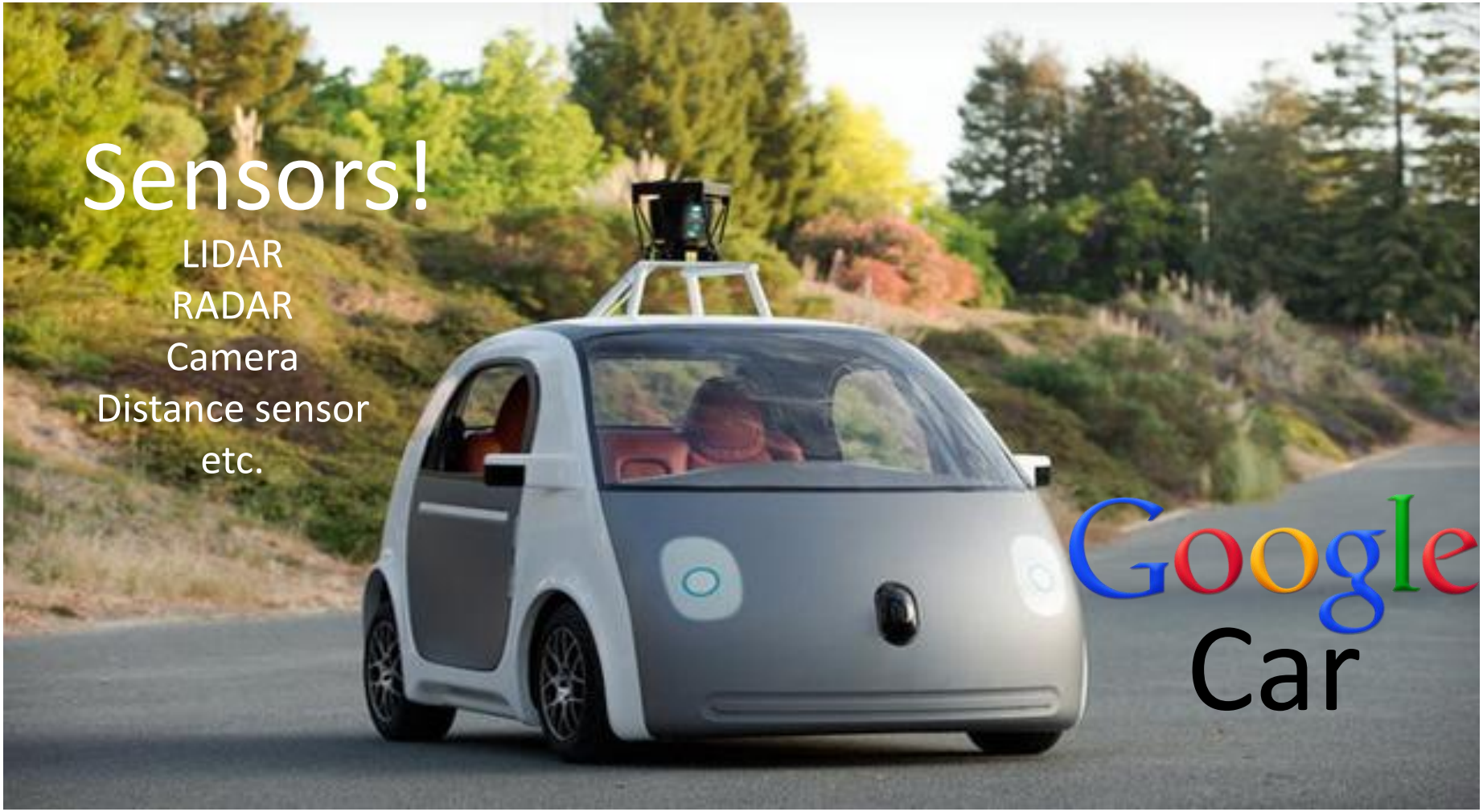
Source of data? Simple case-study

- My vehicle breaks-down
- Disseminate DENM: Stationary Vehicle Warning
  - Position: ✔
  - Vehicle identification: ✔
  - Time: ✔
  - Cause and estimated end of event: ✔
  - Lane-level information: ✗

Source of data? Simple case-study

V2X communication needs complex sensors, which are able to feed the communication unit!

Google Car (again)



Why V2X ~~instead of~~ and sensors?

Cooperation is a must for autonomus driving!
Driving is a multiplayer game played in real-time!

Less processing load
Quicker processing
Cooperation
Message exchange (e.g. notifications)

Fully (cooperative) autonomus driving won't exist without V2X communication

Q&A time