Shared Autonomous Mobility

Kunal Chandra, Vice President,
December 2019, Berlin

Urban megatrends in 2030 indicate a high demand on city infrastructure systems

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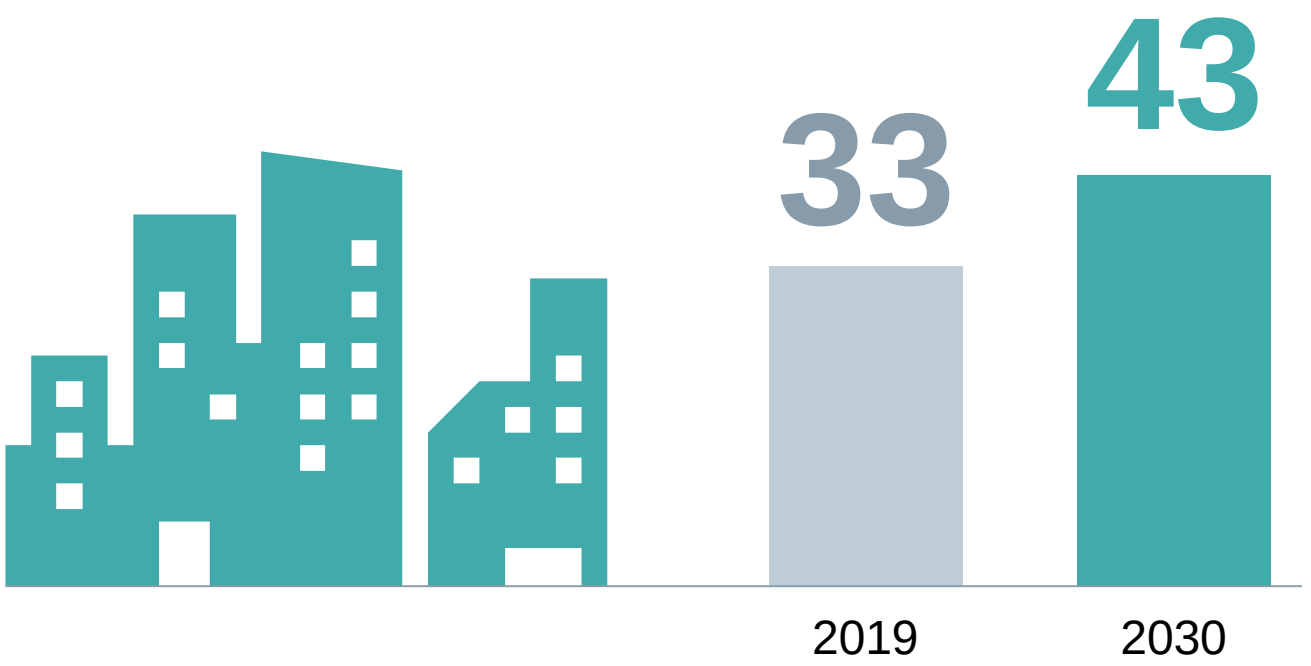
People moving to cities

790 million

More megacities

Cities with a population over 10 million



Source: United Nations Population Division

Ride hailing cabs unlikely to solve urban mobility problems with only up to 60% utilization rate in even highly urban centers

Ride hailing cabs occupancy rate (in percentage)

Source: Fehr and Peers study commissioned by Uber and Lyft

Our AV-DRT shuttle system allows for safe, cost competitive, reliable, responsive & profitable public transport operations

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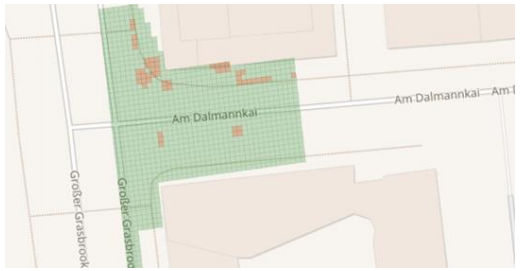
Solution

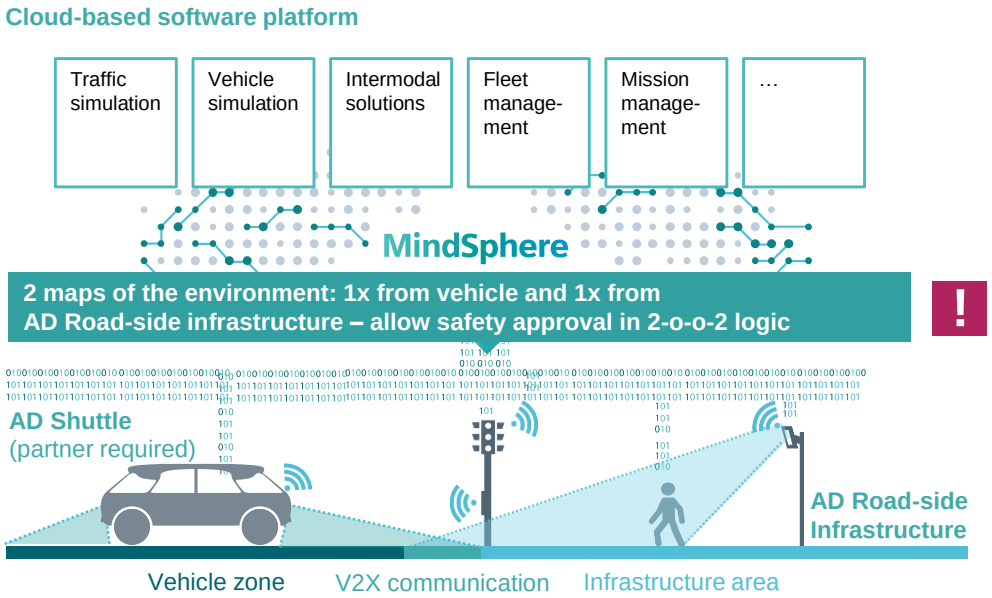
AD Road-side infrastructure
At traffic critical points



AV-DRT shuttle system for public transport
On-demand or fixed scheduled first/last mile services

Cloud-based software platform
Simulation, intermodal solutions, fleet management

Integrated cybersecure system



AV-DRT shuttle system consists of AD road-side Infrastructure and cloud-based software platform

+

Integration of different AD shuttles from partners (vehicle agnostic system)

Customer benefits

Significant OPEX reduction
>60% lower costs compared to conventional bus operations

Earlier homologation –
5 years earlier compared to systems w/o infrastructure support; no blind spots on the road

Technology boost
Cities and PTOs become competitive against Uber, Lyft, etc.

Allows for new business models
Demand-driven mobility services, attract new customers

Congestion free cities
Avoids short distance individual ride hailing. Higher energy efficiency through shared mobility

AD: Autonomous Driving | **AV:** Autonomous Vehicle | **DRT:** Demand-Responsive Transportation | **PTO:** Public Transport Operator

Infrastructure provides an additional “pair of eyes” for the shuttles resulting in safer and more comfortable passenger experience

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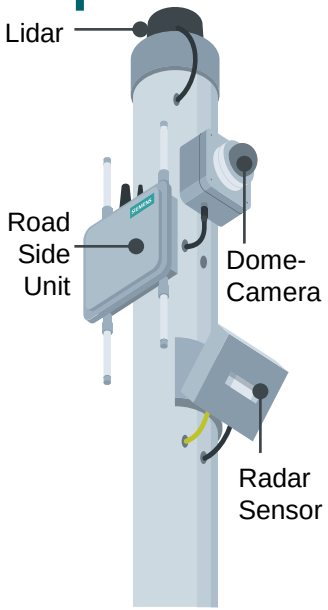


Real time requirements

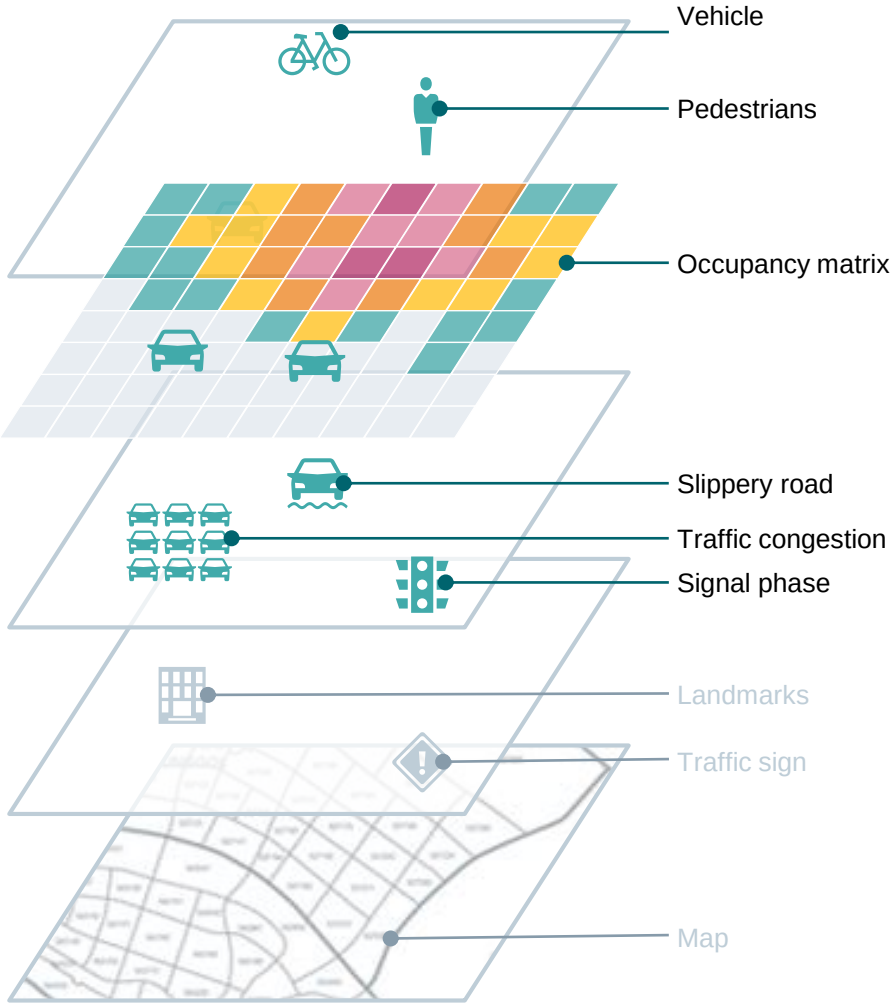
Layer 5
Highly dynamic data

Layer 4
Occupancy grid

Layer 3
Transient dynamic data

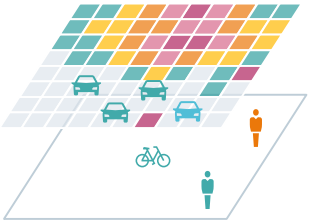
Layer 2
Road-side infrastructure

Layer 1
Map data

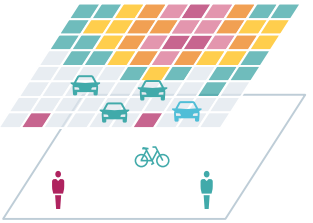


Processing unit Traffic cell control computer

Intelligent infrastructure + **Autonomous vehicle**



1 information layer



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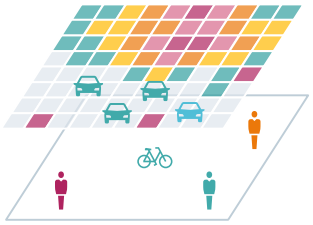

Combined information of independent layers

Enriched and extended
environmental perception for an AV

In certain situations, the role of infrastructure becomes highly critical

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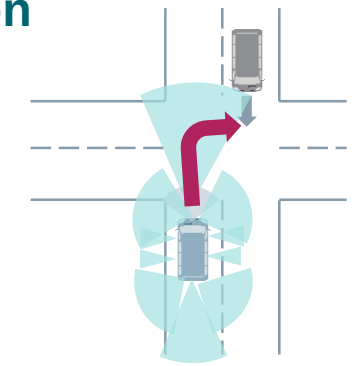
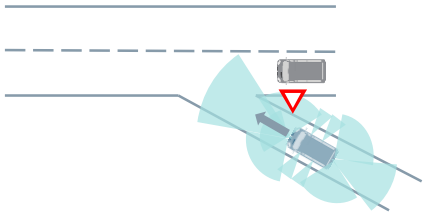
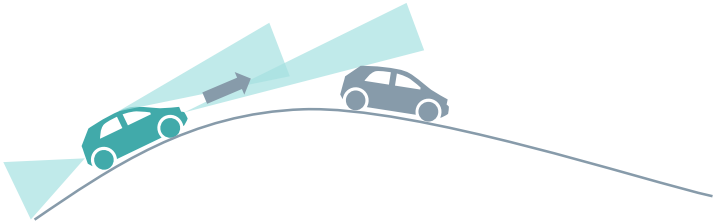
Roadway junction



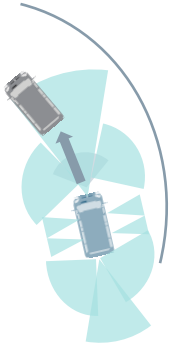
Roadway connectivity



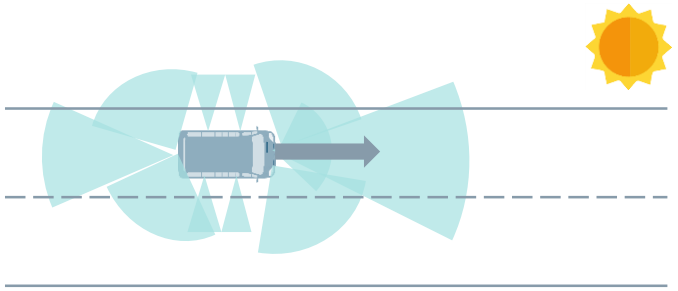
Steep hill scenario



Hairpin turn



“Sun blinding” of sensors



Localization

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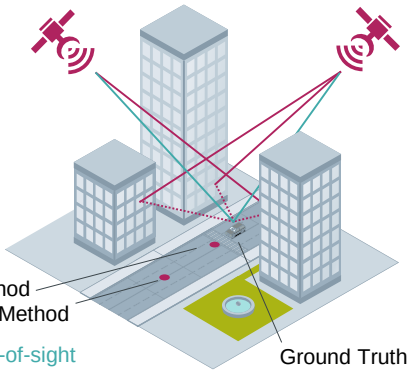

Higher road safety | **Increased road efficiency** | **Mobility system improvements**

Second source of information likely to shorten time to homologation for autonomous shuttle services

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Faster homologation

Challenges

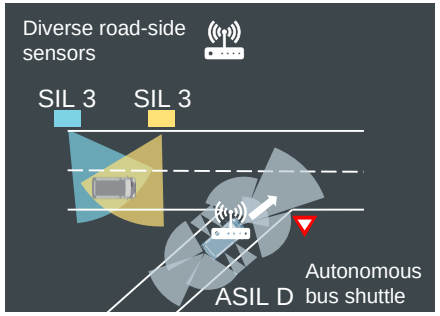
Globally no legal framework in place that judges autonomous driving	Technical standards and norms need to be revised to cover the requirements of autonomous systems	New set of risks consisting of human/machine interaction with machine dependency

Solution

Digital Twin: Verification and validation with simulation

- Intensive testing in a virtual environment (vehicle/infrastructure) with a pool (~10^6) of dedicated real-life scenarios
- Hardware in the Loop (HiL): Test of embedded systems and its control algorithms by outputting actuator control signals

Benefit: Simulation achievements can be fast and with less efforts implemented in the development



Additional information for the vehicle by road-side infrastructure

- Detection, sensor data fusion and object classification by a smart pole consisting of sensors like lidar, radar and camera
- Trustworthy signal (SIL 3) transmitted from the infrastructure (occupancy grid) to the vehicle through a secure communication channel

Benefits: Enhanced environmental perception, valuable support from a second source for driving decisions

AD infrastructure incl. simulation tests of an AD system significantly helps to overcome homologation challenges – we expect time savings of 50% for permits for an AD infrastructure supported system compared to stand-alone vehicle solutions.

At Siemens we combine wide range of expertise for end to end development, validation and deployment of AV-DRT systems

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Traffic simulation

aimsun.
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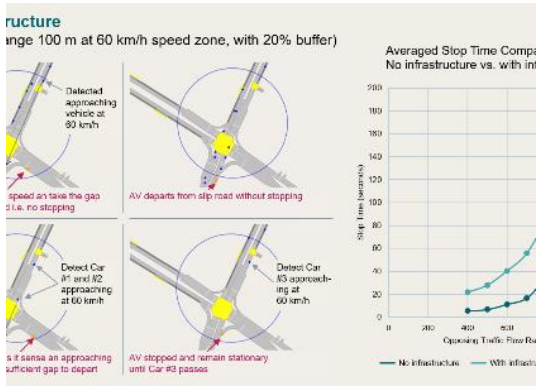

Verification & validation

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Mobility management

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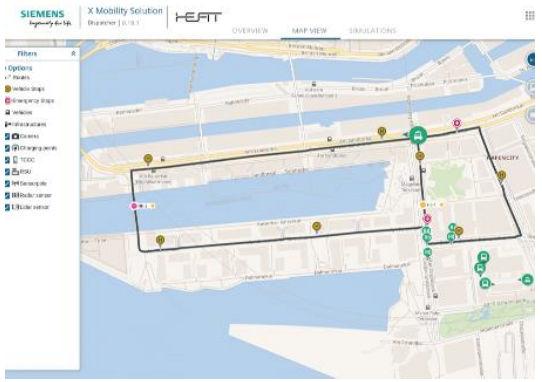

Intermodal solutions

HaCon

Drive new product development

Use the strengths of the Siemens eco-system

Verification and validation

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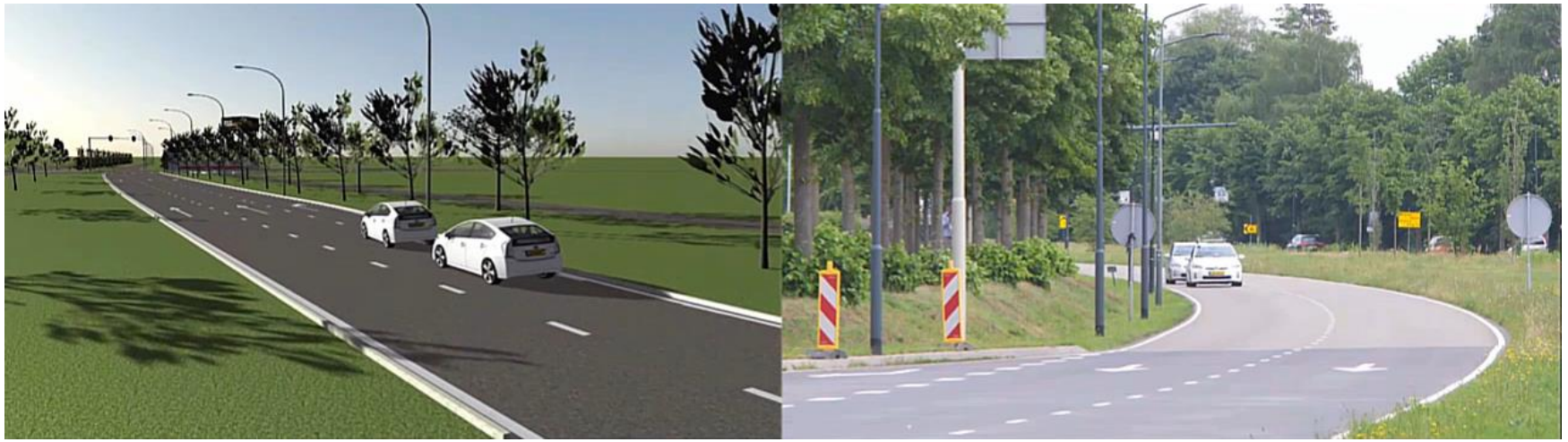
Scenario simulation using vehicle sensors and **V2V** automation limits **turn at intersection to 10 km/h**

V2V



Scenario simulation using vehicle sensors, **V2V and V2I** turn at intersection can be executed at **25 km/h**

V2V and V2I

Fast pace development through deployment in strategic projects in partnership with our key customers

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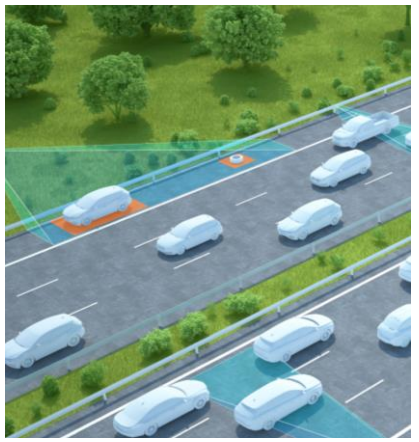

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Other projects

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