Connected Navigation for Highly Automated Driving

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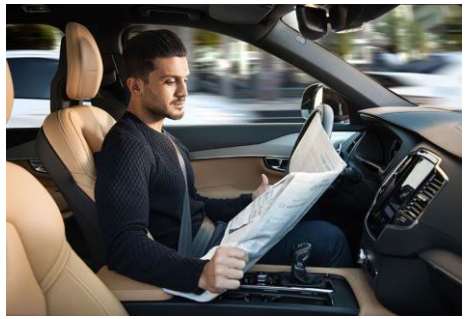
Automated Driving – The Vision

wepods.com



volvocars.com

google.com

mercedes-benz.com

Key goals of automated driving

- Increased safety based on the assumption that automated vehicles will cause less accidents than manually operated cars
- Enhanced driving comfort and possibility to work, relax or access entertainment while driving
- New mobility models based on driverless taxis/shuttle services
- Freeing up of city land due to more condensed and/or off-site parking capabilities of future automated cars
- Less traffic jams and improved traffic flow by automated driving

Automated Driving – Piloted Driving Today

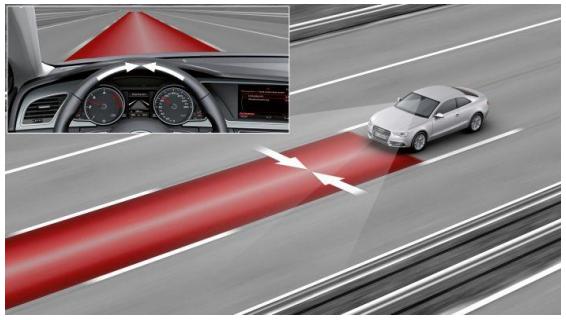
Mercedes Drive Pilot
incl. Active Lane-Change Assistant

Mercedes-Benz Deutschland

Tesla Autopilot
incl. Auto Lane Change

www.tesla.com

Audi Active Lane Assist
and Predictive Efficiency Assistant



www.audi.com

BMW Active Driving Assistant Plus

www.bmw.ch

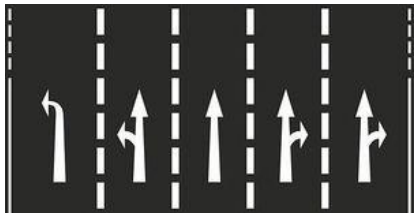
- **Speed Control**
  - Adjust speed according to set maximum speed and traffic ahead
  - Advanced systems additionally adjust speed according to the topography of the route and speed limits
- **Steering Control**
  - Follow current lane and/or car for a certain time
  - Perform lane change manually triggered by driver

Piloted Driving – Closing the Gap

Combining reactive, tactical, and strategical planning for automated driving

Today

Reactive planning
on lane/geometry level
~ 10 sec

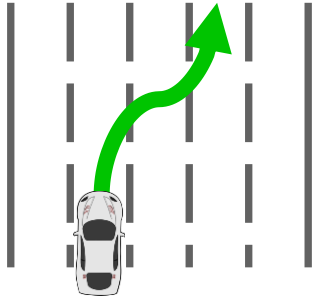


- Computes AD vehicle trajectories based on lane change advice
- consideration of surrounding traffic and sensed road characteristic (e.g. lanes)

Sensor/object data (camera, radar etc.)

Next Generation

Tactical AD planning
on lane level
10 – 60 sec



- Generates lane change directives according to currently driven lane and lane situation for upcoming maneuvers along the route

HAD map with detailed lane info
Lane accurate positioning

Future

Strategic AD planning
on edge level
60 – ∞ sec

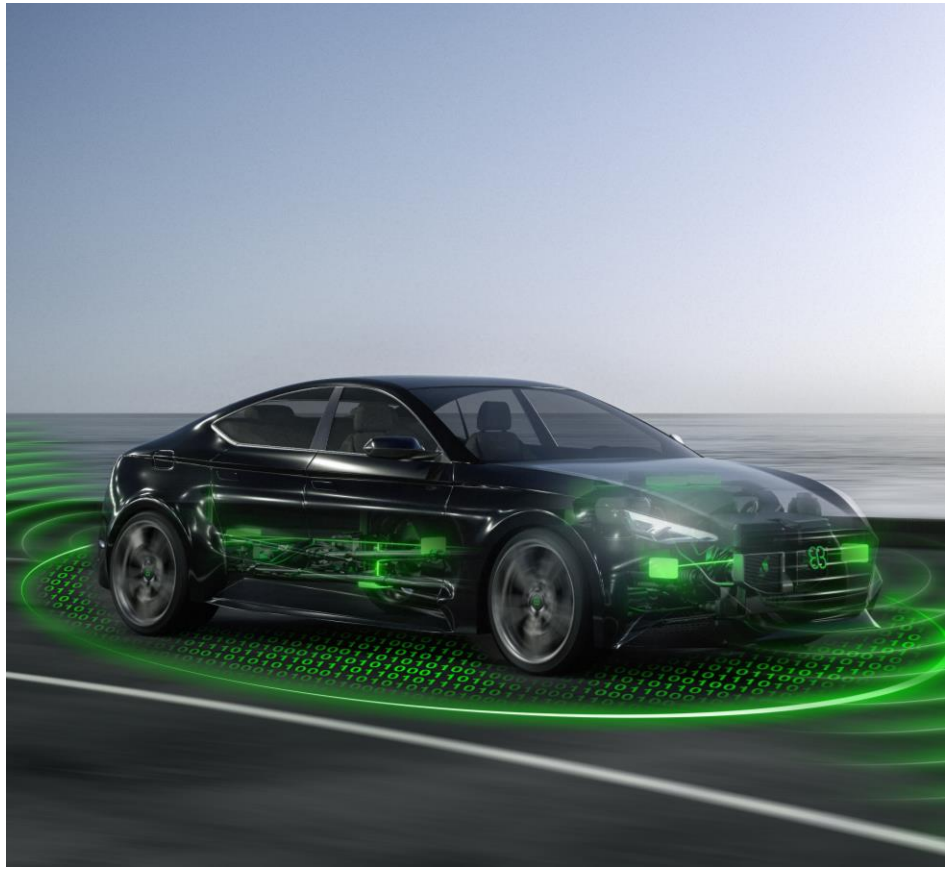
- Provides the route to a selected destination for an AD drive
- Suitability of road segments to be considered for route calculation

Extended Navigation Map

Piloted Driving Today – Reactive Planning

Characteristics

- **Current AD systems relying heavily on locally sensed data**
  - Typical sensor set: camera and radar
  - Lane geometries based on camera sensed lane markings for steering control
  - Object detection for velocity control and collision prevention
- **Map data only used to certain extent**
  - Road class for system activation/deactivation
  - Speed limits and road geometries for speed control
- **Lane changes not triggered automatically**
  - Driver initiates lane change

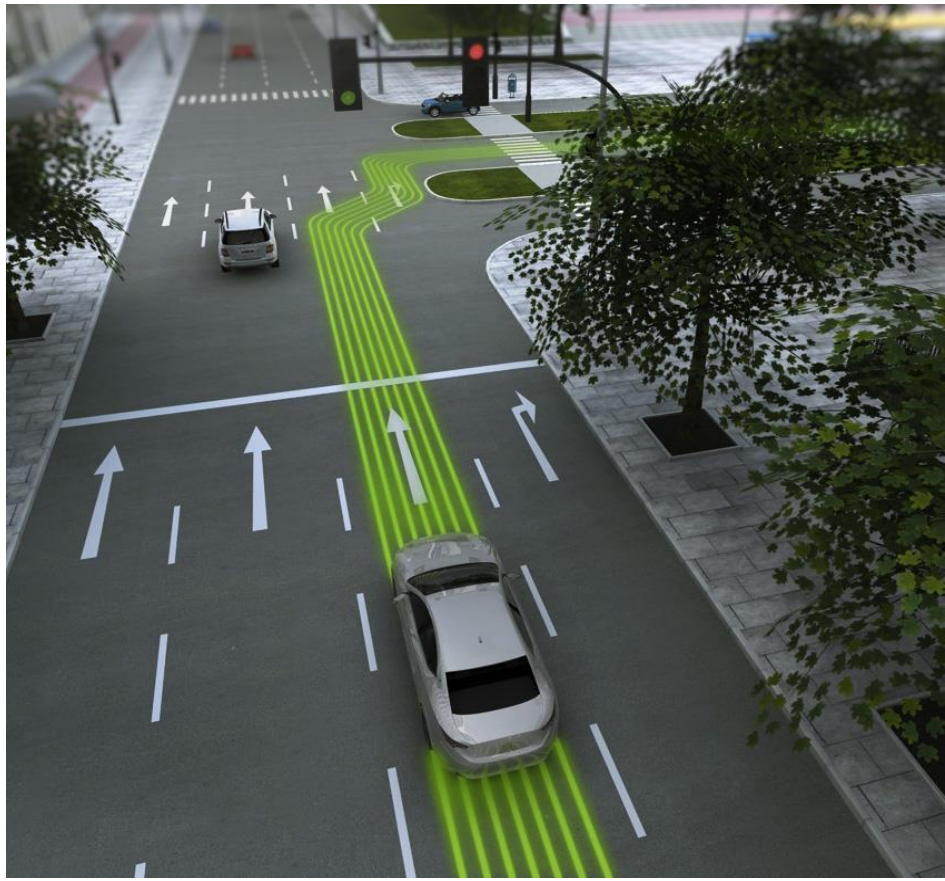


Piloted driving uses locally sensed data, driver triggers activities

Piloted Driving Next – Tactical Planning

Lane choice along the route

- **Selection of suitable lanes along the route**
  based on map data with detailed lane information (e.g. lane connectivity, lane marking types)
- **Determination of current lane**
  based on HAD map with detailed lane information (e.g. lane geometry)
- **Planning of required lane changes**
  based on current lane and recommended lane(s)
- **Hand over of lane change advices**
  to active lane-change assistant



Combination of lane accurate map matching and lane accurate maneuver generation based on HAD map data

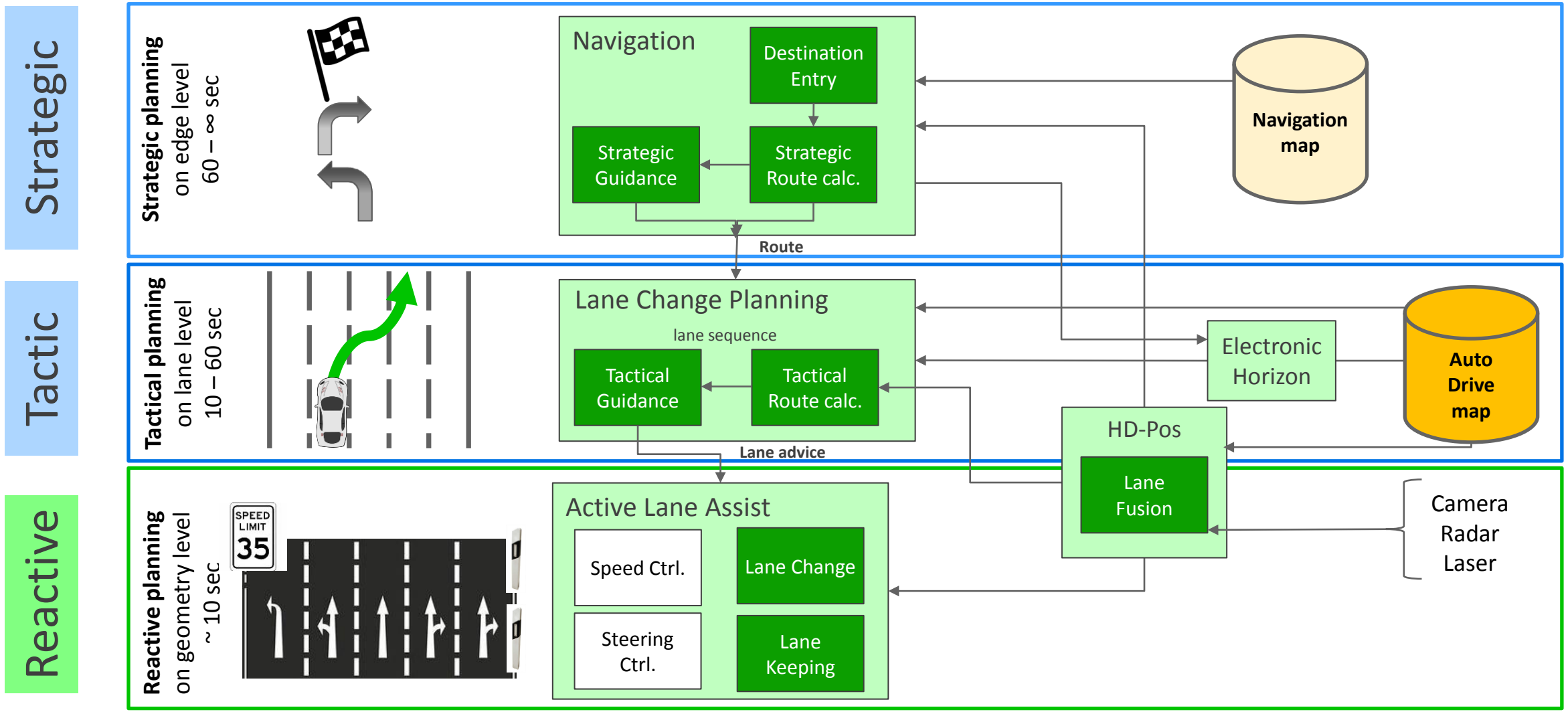
Piloted Driving Next – Strategical Planning

Selection of a suitable route

- **Autonomous Driving is based on routing to a destination**
- **Route calculation using suitable AD road preferences for entire trip**
  - Route selection with smallest possible route segment distances that are not suited for AD
  - Routing needs to consider parameters like road class, lane separation and ADAS accuracy in addition to route length and travel time
- **Route might be updated while driving based on dynamic information**
  - Traffic situation
  - Local hazard and warnings

Routing technology provided by common navigation systems based on extended navigation map data

Architecture: Reactive - Tactic - Strategic



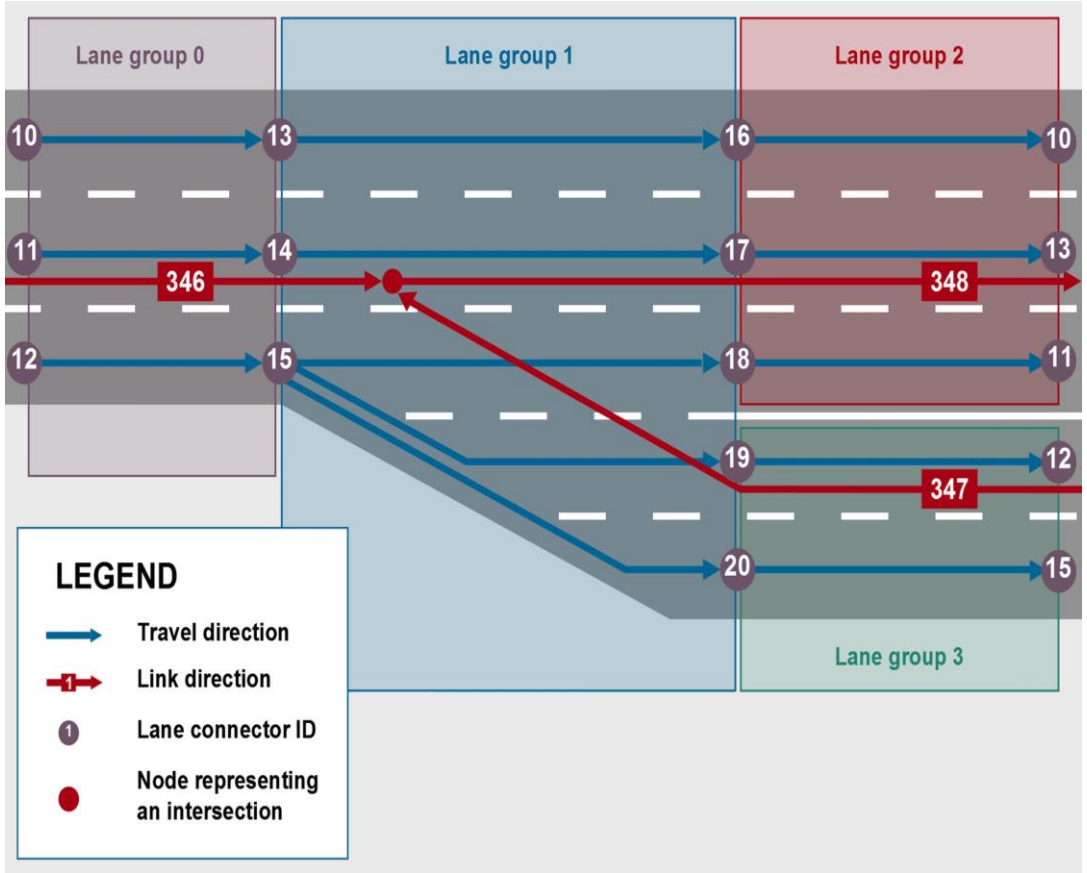
Map Data for Automated Driving

HAD map data for automated driving

- **AD support for areas with continuous lane markings**
  - Precise lane information is needed for lane accurate positioning and tactical planning of lane changes
  - Required data includes lane geometry, lane markings and lane connectivity
- **Extensions required for areas without continuous lane markings**
  - Geometry of driving path(s) along road segments
  - Geometries of intersection internal lane transitions
- **Incremental Updates**
  - Incremental database updates of lane geometry, lane markings and lane connectivity

HAD map data is a crucial prerequisite for automated driving

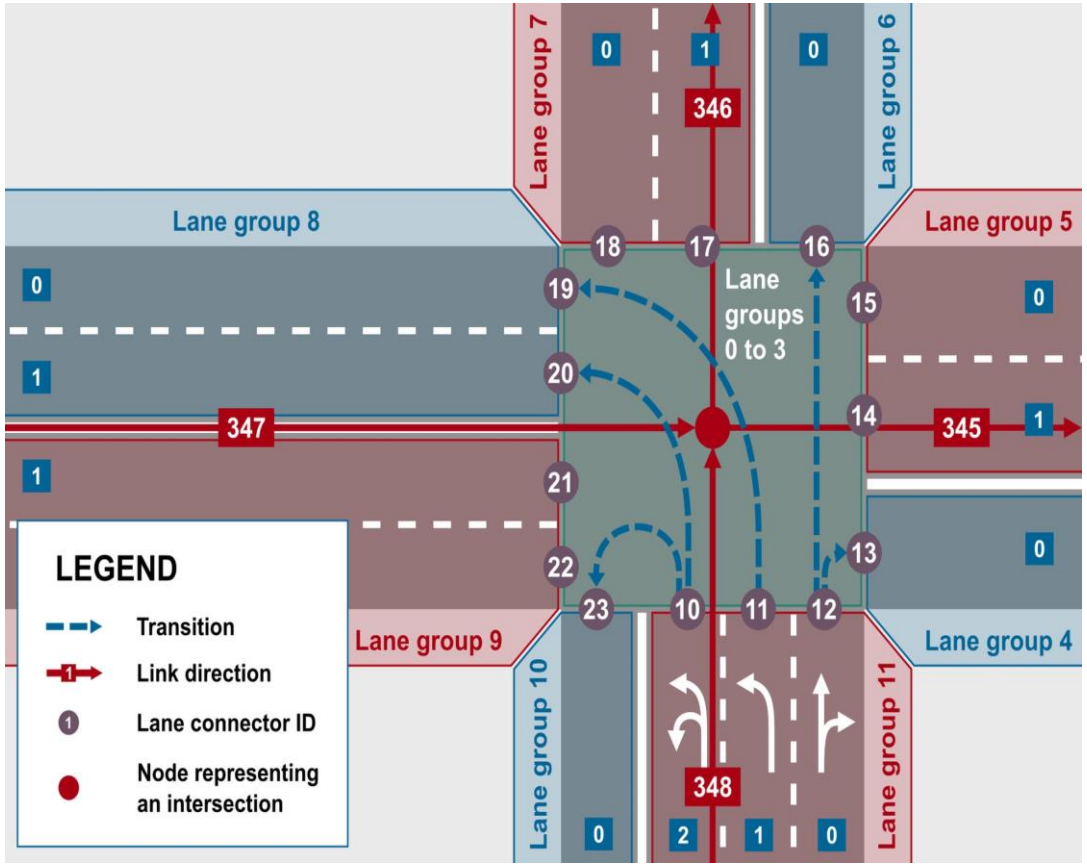
Lane Connectivity



- Detailed Lane Topology
- Lane Connectivity
- Inter-connection between lanes
- Up to 1-cm resolution
- Lane direction

Image: Open Lane Model Specification

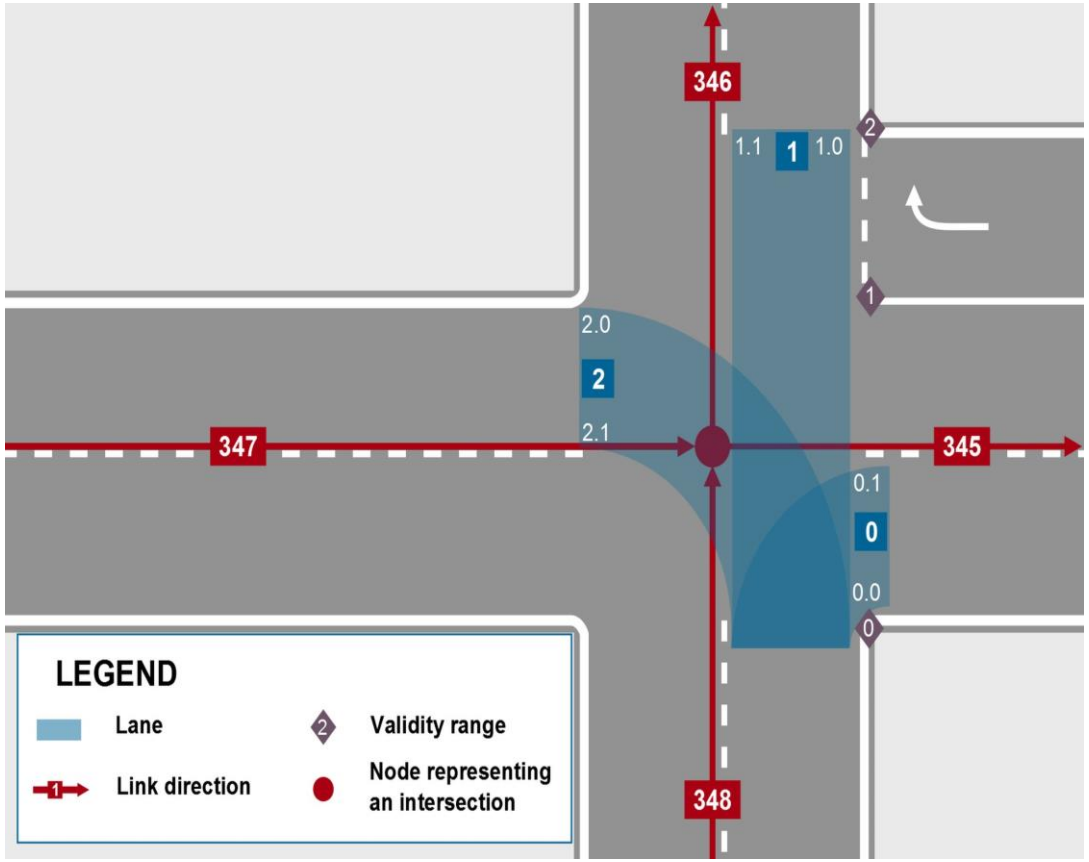
Lane Transitions across Intersections



- Complex Intersections
- Detailed lane connection for turns and U-turns
- Detailed lane geometries for driving
- Lane markings

Image: Open Lane Model Specification

Lane Boundaries at Intersections



- **Boundary Definitions**
- **Detailed information about lane widths**
- **Lane boundaries and curb walls**

Image: Open Lane Model Specification

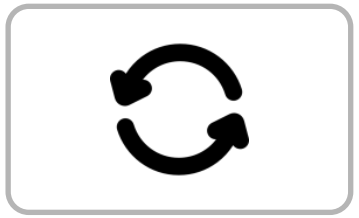
Standards for Automated Driving

Standardization

- NDS Working Group 3 AutoDrive is working on the definition of maps for automated driving
- NDS Association has publically released the NDS Open Lane Model
- NDS Working Group 2 “Hybrid“: concepts for loadable map data and volatile data
- ADASIS Forum is working on a new version of the ADASIS protocol allowing the distribution of lane accurate AD map data within the vehicle
- Open Auto Drive Forum acts as cross-domain platform driving standardizations in the area of automated driving
- Open Auto Drive Live Map Delivery Chain Taskforce: Coordination of TISA and NDS activities regarding dynamic services for autonomous driving
- TISA TPEG: Introduction of lane level accuracy for traffic information

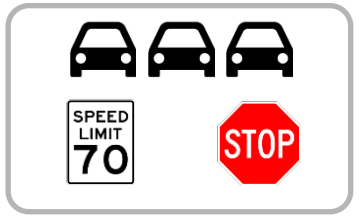
Images: Open Lane Model Specification

Connected Services for Automated Driving



Dynamic map download of Auto Drive map data

- Increased size of HAD maps caused by increased level of detail
- Need for always up to date map data



Dynamic information with lane accuracy for best-possible usage within HAD services

- Traffic information
- Dynamic opening of hard shoulder, variable speed signs


Get in touch!
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