From navigation towards autonomous driving – How maps and dynamic services support

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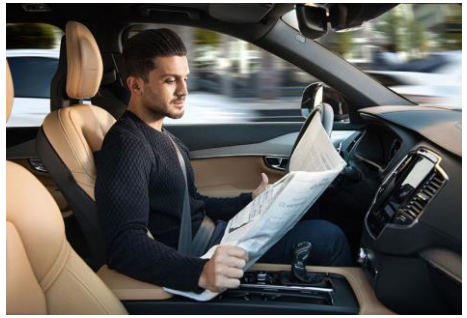
Elektrobit

Autonomous Driving – The Vision

wepods.com



volvocars.com

google.com

mercedes-benz.com

Key goals of autonomous driving

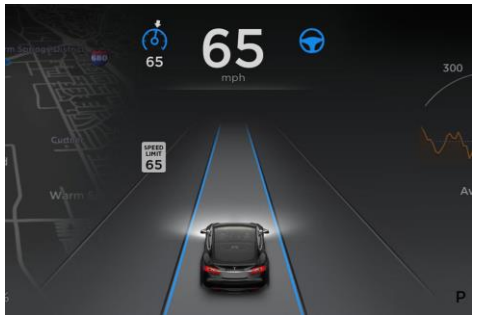
- Increased safety based on the assumption that autonomous vehicles will cause less accidents than manually operated cars
- Enhanced driving comfort and possibility to work, relax or access entertainment while driving
- New mobility models based on driverless taxis/transport
- Freeing up of city land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

Autonomous Driving – Piloted Driving Today

Mercedes Drive Pilot
incl. Active Lance-Change Assistant

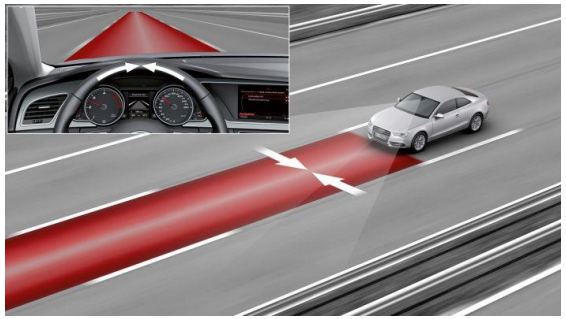
Mercedes-Benz Deutschland

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

Major Scope

- **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 – Next Steps

Combining strategical, tactical and reactive planning for autonomous driving

Future

Strategic AD planning
on edge level
60 – ∞ sec

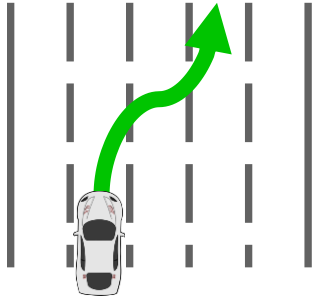
- Provides the route to a selected destination for an AD drive
- Suitability of road segments to be considered for route calculation

Extended Navigation Map

Route

Future

Tactical AD planning
on lane level
10 – 60 sec



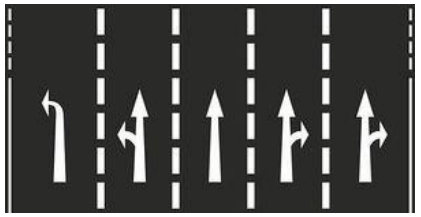
- Generates lane change advices according to currently driven lane and lane situation for upcoming maneuvers along the route

HAD map with detailed lane info
Lane accurate positioning

Lane Change Advise

Today

Reactive planning
on lane/geometry level
~ 10 sec



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

Sensor/object data (camera, radar etc.)

Piloted Driving Today – Reactive Planning

Characteristics

- **Current auto drive systems are heavily relying 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 extend**
  - e.g. 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 – Strategical Planning

Closing the gap: Selection of a suitable route

- **Autonomous Driving is based on a routing destination**
- **Route calculation using suitable AD road preferences for entire trip**
  - e.g. selection of route with smallest possible length of segments 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 warnings

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

Piloted Driving Next – Tactical Planning

Closing the gap: Choice of lanes along the route

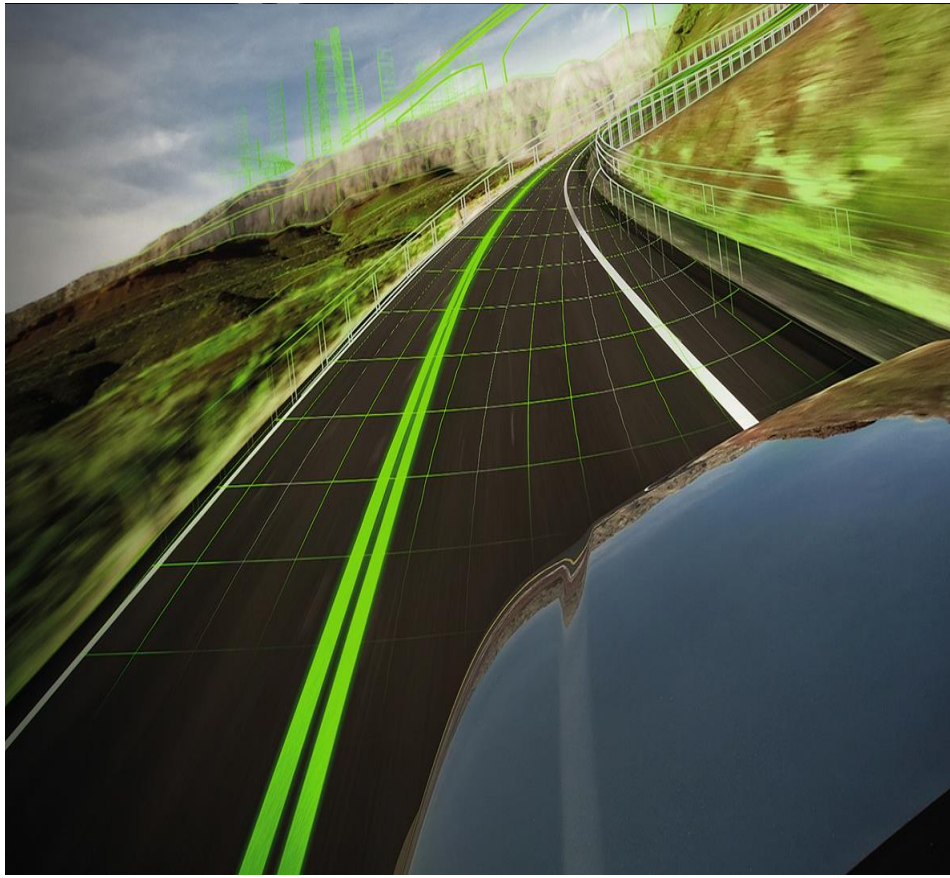
- **Selection of suitable lanes along the route**
  based on map data with detailed lane information (e.g. lane connectivity, lane marking types)
- **Determination of current lane**
  based on HAD map with detailed lane information (e.g. lane geometry)
- **Planning of required lane changes**
  based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

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

Map Data for Autonomous Driving

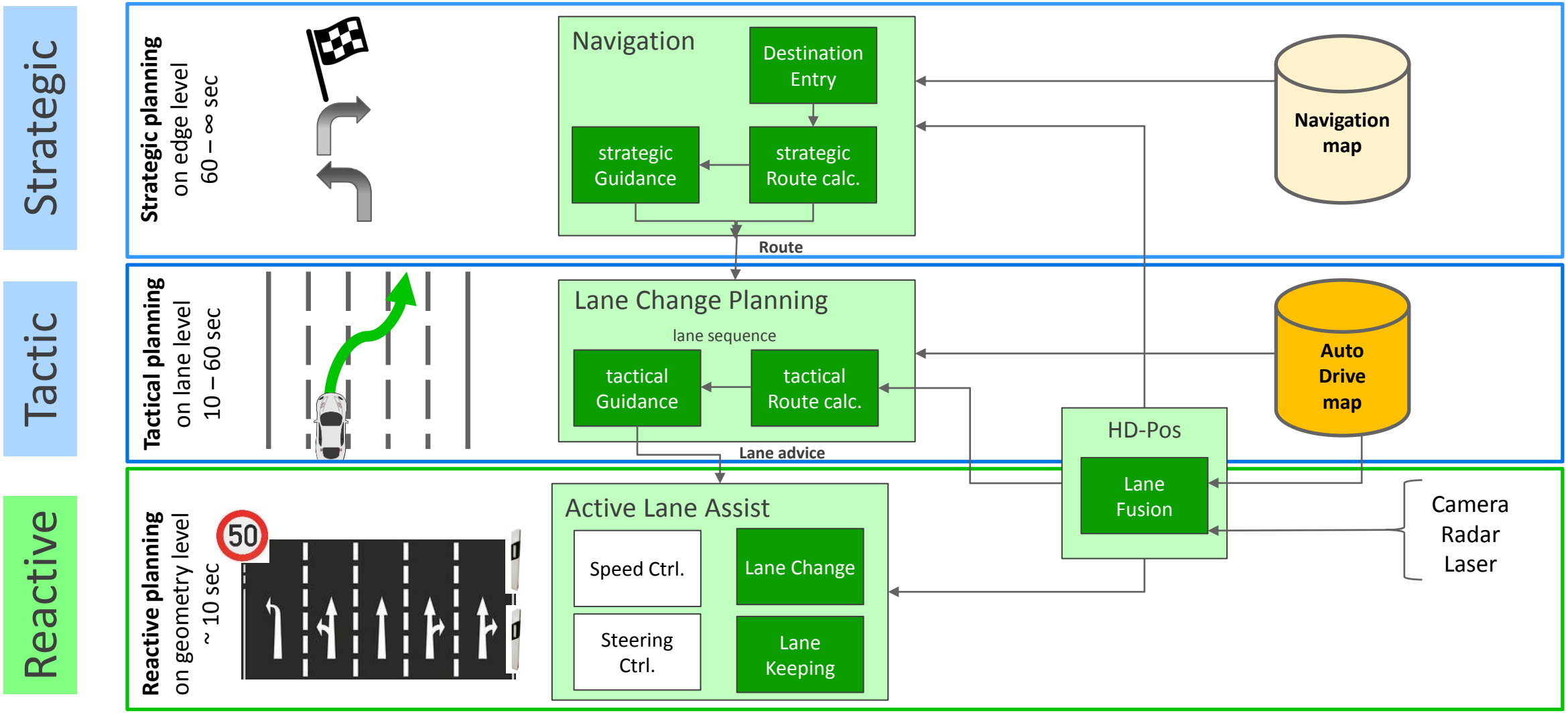
HAD map data for autonomous driving

- **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 geometries, 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



HAD Map data is a crucial prerequisite for autonomous driving

Architecture: Strategic – Tactic – Reactive



Map Data for Autonomous Driving

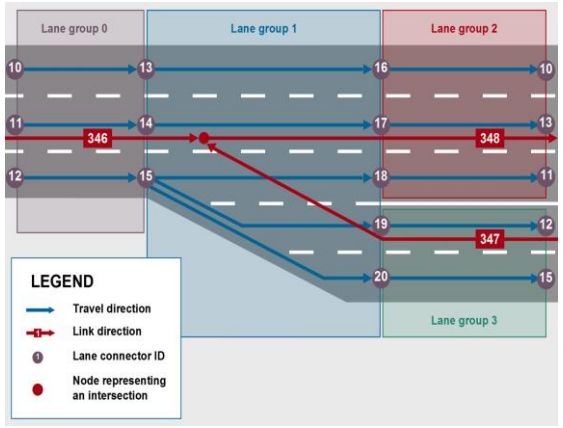
Standardization

NDS Working Group 3 AutoDrive is working on the definition of maps for autonomous driving

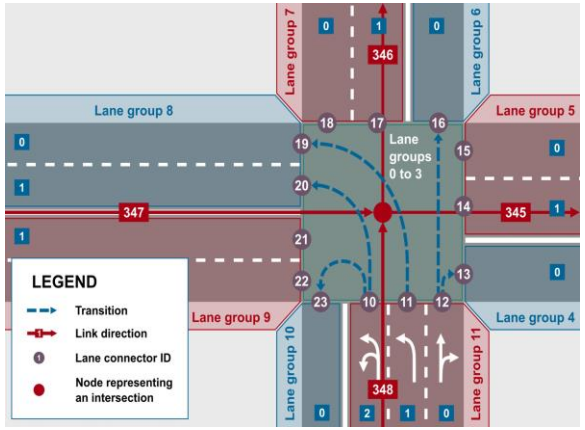
NDS Association has publically released the NDS Open Lane Model

ADASIS Forum is working on a new version of the ADASIS protocol allowing the distribution of lane accurate AD map data within the vehicle

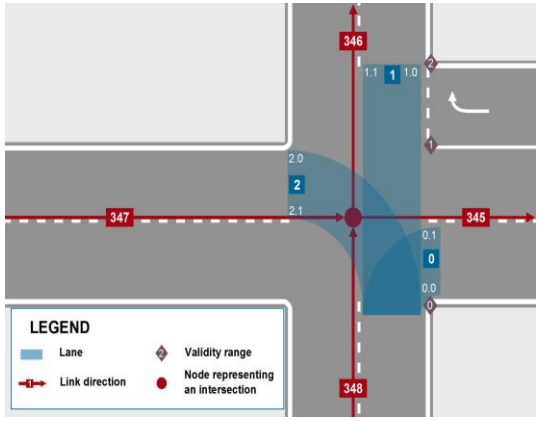
Open AutoDrive acts as cross-domain platform driving standardizations in the area of autonomous driving



Lane connectivity



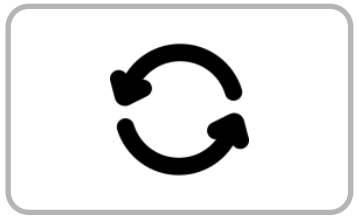
Lane transitions across intersections



Lane boundaries at intersections

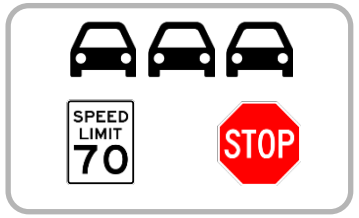
Images: Open Lane Model Specification

Dynamic Services for Autonomous Driving



Dynamic map download of Auto Drive map data can support handling

- 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

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

Standardization consortia already discuss concepts for dynamic services for HAD

- NDS Working Group 2 „Hybrid“: concepts for loadable map data and volatile data
- TISA TPEG: Introduction of lane level accuracy for traffic information
- Open Auto Drive Live Map Delivery Chain Taskforce: Coordination of TISA and NDS activities regarding dynamic services for autonomous driving

Summary

- **Today‘s AD systems requiring driver control**
- **Navigation’s strategical and tactical planning improves AD systems significantly**
- **HAD maps are building the foundation for accurate vehicle positioning and lane change planning**
- **Innovative map update/download concepts and enhanced dynamic services ensure accuracy of HAD data bases**
- **TomTom, Elektrobit are actively contributing with industry key players to further define standards of map data and dynamic services targeting autonomous driving**

Thank you for your attention!

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