Ubiquitous Computing in Business Processes
Part V

Prof. Dr. Lutz Heuser
Urban Software Institute

Darmstadt
WS 2023/2024

Outline

1. Open Urban Platform Use Cases

TRAFFIC APP

Open Data-Traffic APP of the City of Darmstadt

Objectives of the city

- Distribute traffic to reduce / avoid traffic jam situations especially at high peak time, e.g., during commute hours
- Motivate drivers / commuters to consider alternate routes or mobility modalities (bike, public transport, ride sharing)
- Improve overall traffic flow

Traffic APP functionality

- Provide real-time traffic flow information to drivers
- Provide insights on road constructions to allow for alternating routing
- Offer alternate mobility services (e.g., bike sharing services, public transport)

Traffic Light Infrastructure

Traffic Light / Traffic Signal

- are signaling devices positioned at road intersections, pedestrian crossings, and other locations to control flows of traffic.

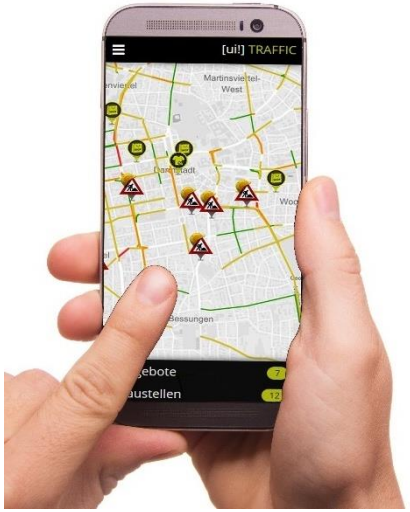
Adaptive traffic control system (ATCS)

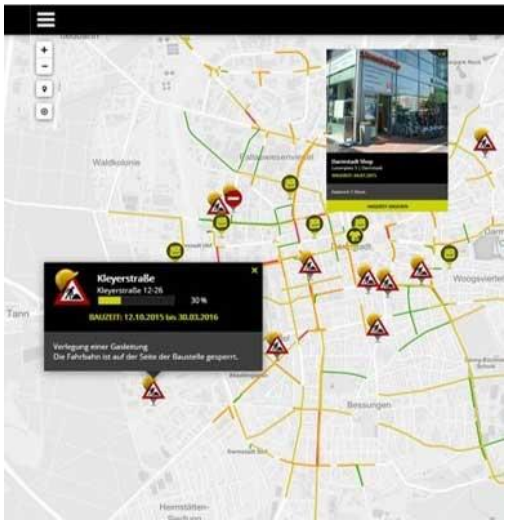
- is a traffic management strategy in which traffic signal timing changes, or adapts, based on actual traffic demand.
- This is accomplished using an adaptive traffic control system consisting of both hardware and software
- Also called Traffic Management Systems (TMS)

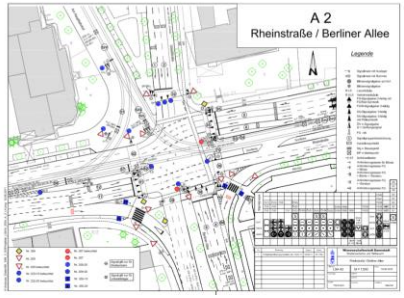
(Traffic Signal) Detectors

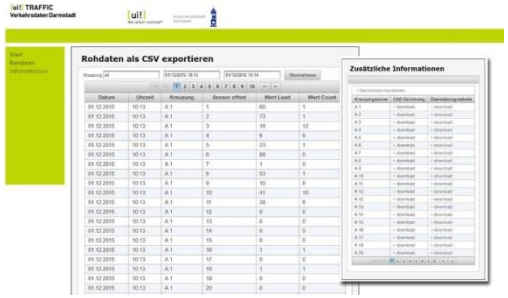
- detects demand of traffic participants (vehicles, pedestrians, bikes, public transport)
- Examples include:
  - Inductive Loop
  - Video Image Processor
  - Switch (for pedestrians)

Open Data-Traffic APP of the City of Darmstadt









Open Data Portal APP

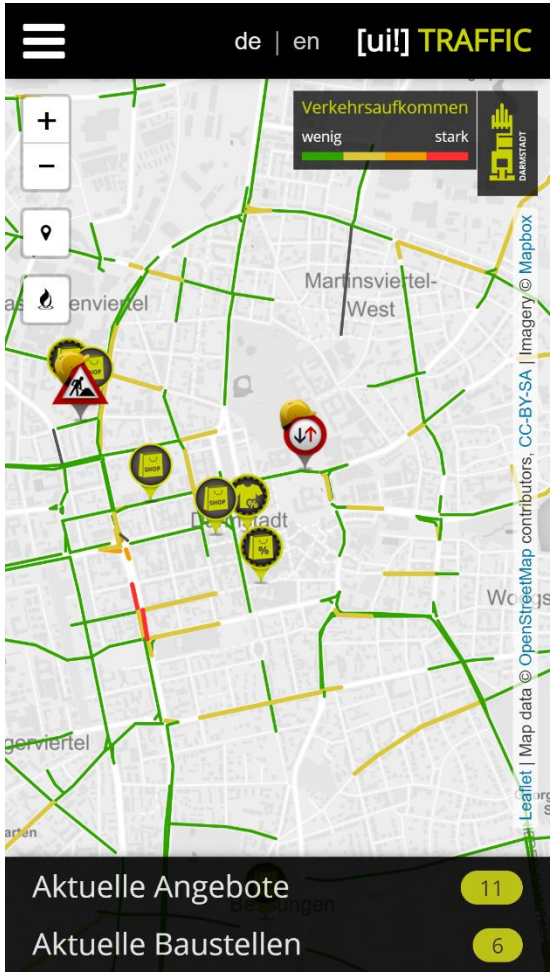
- Detector Values
- Traffic Signal location map

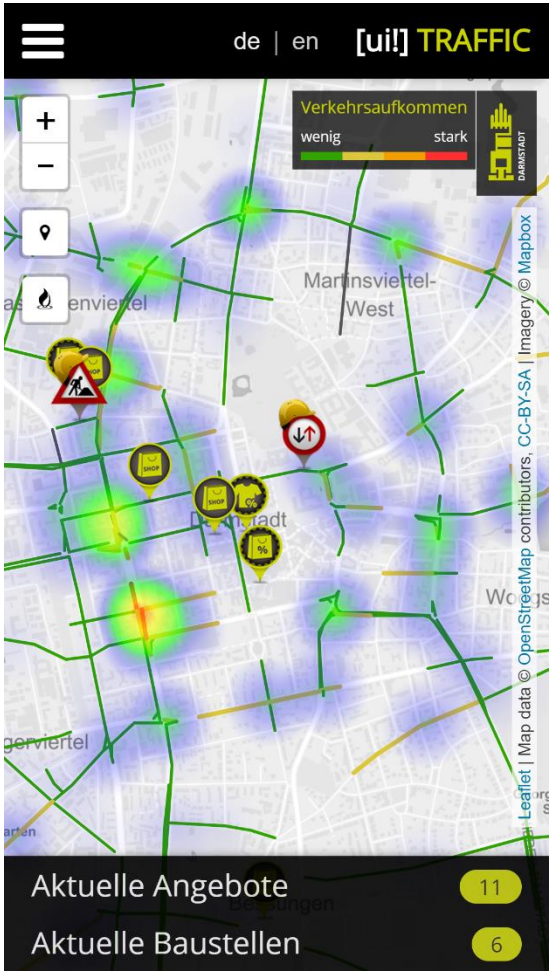
Darmstadt Traffic APP

- Qualitative Visualization of Traffic Flow
- Road Construction
- and other location-based information

https://darmstadt.ui-traffic.de

Realtime TRAFFIC APP





Green Phase Prediction

ECOMAT – Personal traffic signal phase prediction

More Information about the APP (in German):

https://ecomat.ui.city/

[ui!] ECOMAT

Traffic Light Assistance APP [ui!] ECOMAT

Provision of traffic light information via an APP

- Real-time data connection to the traffic management center
- Urban data platform [ui!] UrbanPulse predicts traffic signals
- The driver receives information and recommendations in the smartphone app

The Driver

- uses waiting times at traffic lights with ease
- anticipates and navigates in green waves
- saves fuel, protects the environment

The City

- supports its citizens in environmentally friendly driving
- involves citizens in improving traffic flow
- extends its tools for environmentally oriented traffic management

Why is Signal Prediction a Business Case?

Motivation / drivers for Cities

- Traffic counts for significant air pollution (e.g., NOx, PM) and climate change (e.g., CO_2)
- Improving the traffic flow at signal-based intersection could reduce PM by 27%, NOx up to 33%, and CO_2 by 15% according to reports of the automotive community[1]
- Avoiding surpassing the regulatory thresholds prevents the City to pay fines.[2]
- Improving Air Quality to protect the health of citizens against diseases such as asthma.[3]

Motivation / drivers for the automotive Industry

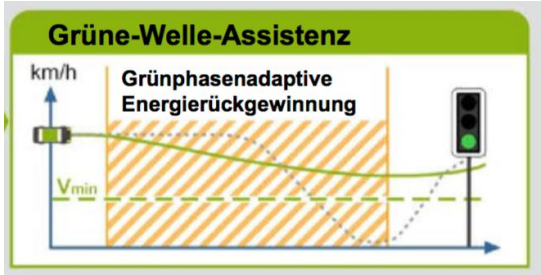
- Passenger cars are responsible for around 12% of CO_2 emission
- Automotive fleets need to adhere to EU Directive of 95g CO2/km[4] to avoid paying fines (excess emissions premium) for each car registered
- Improve driver experiences in times of Digital /Social Media by providing estimates of signal phase change (= waiting time at red signal)
- Improve safety with respect to approaching intersections, e.g., managing speed and braking assistance

[1] luftreinhaltung-massnahmenkatalog-adac-nordrhein.pdf (in German)
[2] „Saubere Luft“ für Darmstadt: Deutsche Umwelthilfe, ökologischer Verkehrsclub VCD und Land Hessen einigen sich auf Maßnahmenpaket – Deutsche Umwelthilfe e.V. (duh.de) (in German)
[3] euhttps://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE-LEGAL-ACTIONS_Right-to-Clean-Air_DE.pdfropa.eu
[4] Reducing CO2 emissions from passenger cars - before 2020 | Climate Action (europa.eu)

Signal data for the Automotive Industry

Goals

- ✓ Information and Comfort
- ✓ Safety
- ✓ Traffic Flow
- ✓ Emission reduction
- ✓ USP (Unique Selling Point)



Example
Green-Phase-Assistant
(UR:BAN 2016)[1]

Concepts

→ Support functions
- Brake Assistant
- Start/Stop-Automatic
- ...
- Up to autonomous driving

→ Human-Machine-Interface
- Simple Visualisation
- Time-to-green
- Speed recommendation
- Warnings
- Additional information such as emissions

[1]URBAN_Leithttps://www.bgu.tum.de/fileadmin/w00blj/vt/Projekte/Urban/URBAN_Leitfaden.pdffaden.pdf (tum.de)

[ui!] TRAFFIC – a Platform-driven traffic flow analysis and prediction solution

The city provides real-time data and system information

Open Data Portal and Citizens APP

Tools for Quality Management

TMS

Connector

Raw data

Inbound interfaces

[ui!] TRAFFIC / [ui!] UrbanPulse

Signal prediction

Realtime-Data Analysis.

Outbound interfaces

SPaT/MAP

Automotive Backend

Roh-daten

Light Control

Predict ions

Fahrzeug

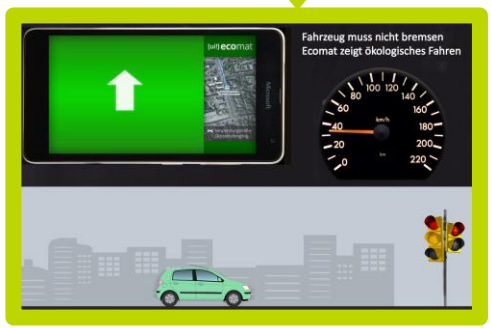
Fahrzeug

Car

HMI

ADAS

drivers use the traffic light phase assistant [ui!] ECOMAT when driving in the city



Traffic Flow Analysis and Prediction Solution

1. Traffic Management System (TMS)
   is in charge to manage all traffic signals and signal phase plans,
   provides signal phase change records (Smart Items data as „raw data in line with DIN SPEC 91357))
2. CONNECTOR
   takes the phase change records and sends it to the urban data platform (local connector deployment)
3. The raw data is taken via the inbound workers, stored and provided to the processing layer of the urban data platform
4. In the processing layer, the analytics module calculates based on historical data and the current phase change data (raw data) the predicted signal phase change as „smart data“ in line with DIN SPEC 91357
5. The „smart data“ signalphase prediction is provided via outbound workers to different smart services and the automotive backend (aka management systems)

6. Applications could be
   a. Open Data Portal for providing the raw data
   b. Applications used by the City traffic management department (e.g., QM tools)
   c. ECOMAT APP and the like
7. Management Systems could be Automotive Backends using the smart data to use within their own context, e.g. Advanced Driver Assistance Systems)

ADAS – Advanced Driver Assistance Systems

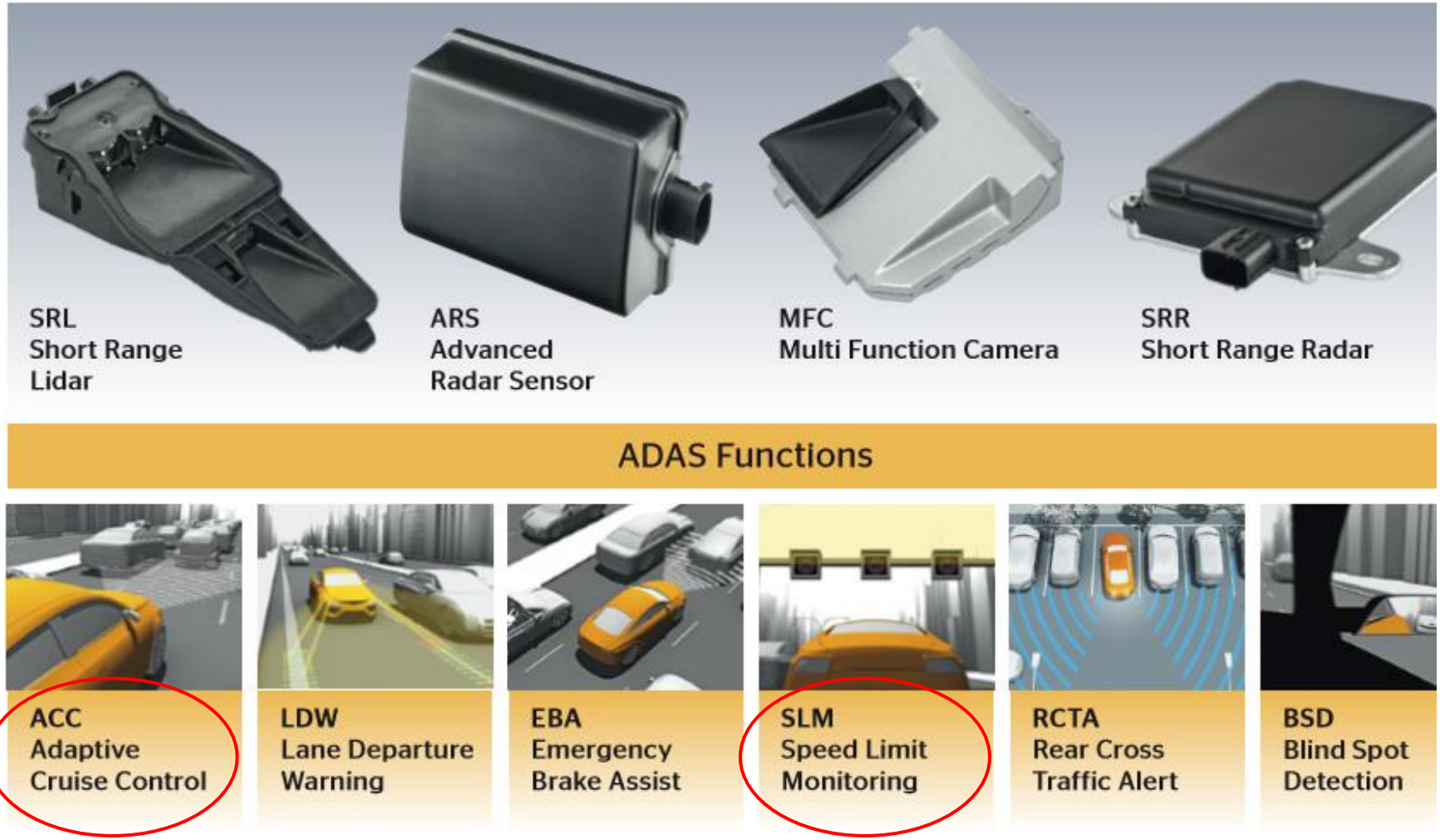
Objectives of ADAS:

- Safe driving
- Multiple different hazards require quick, considerate action without losing sight of further traffic every second.
- help drivers stay on top of things, helping them arrive safe and relaxed.
- act as electronic copilots, providing driving comfort and make driving safer and stress-free.
- make the road traffic safer and are an essential part of the vision of accident free driving.

=> Signal phase prediction could help to support these objectives

Source: Continental Corp.

ADAS – Advanced Driver Assistance Systems (Smart Items)



Source: Continental Corp.

Use Cases of ADAS for Signal Phase Prediction

ACC- Adaptive Cruise Control[1]

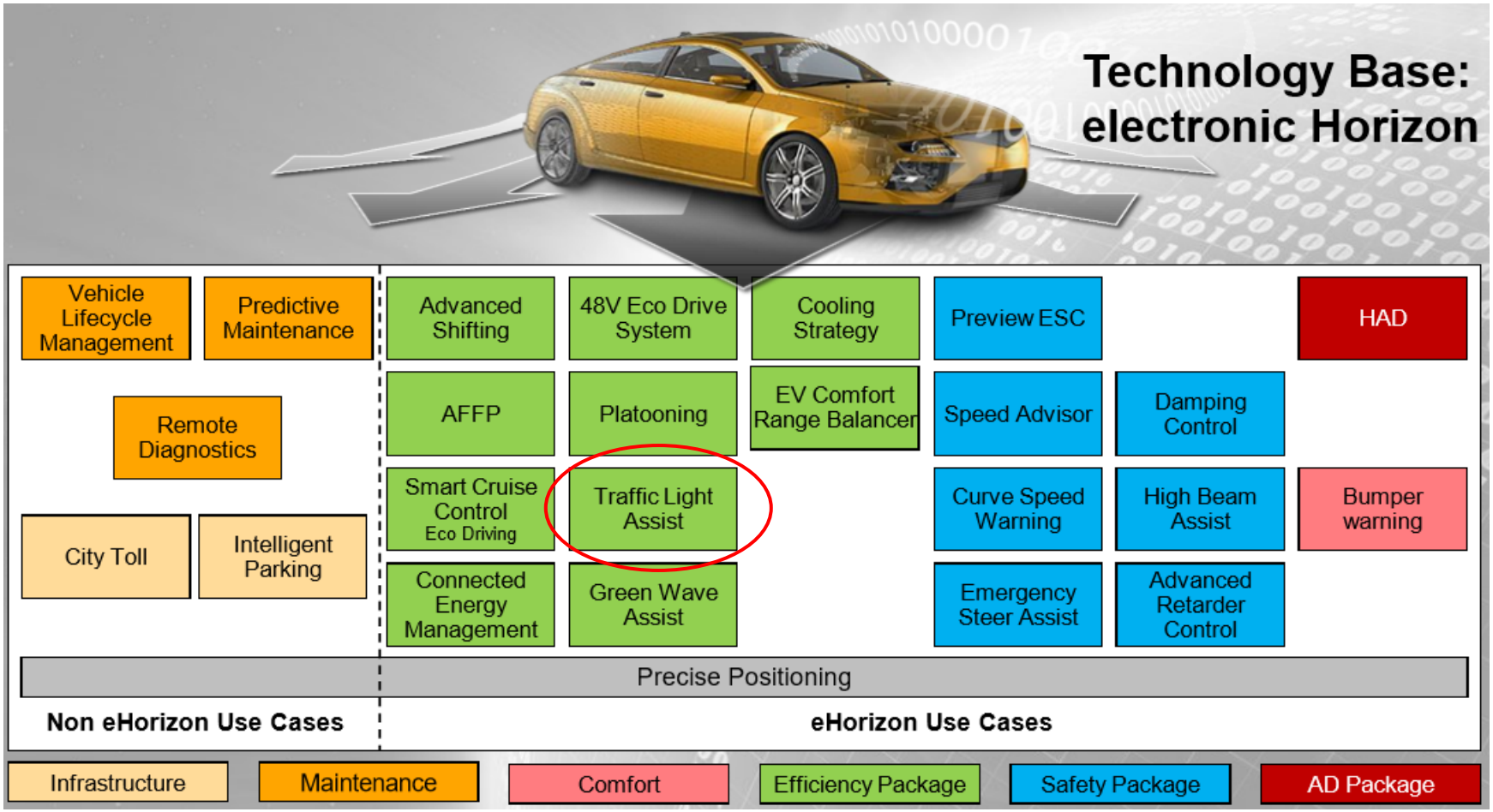
- Safety feature to keep distance to cars
- Manages the power engine
- Help avoid traffic accidents

SLM – Speed Limit Monitoring

- Also called Intelligent Speed Assistant
- Closely related to ACC
- ISA uses a speed sign-recognition video camera and/or GPS-linked speed limit data to advise drivers of the current speed limit and automatically limit the speed of the vehicle as needed.[2]

[1] Wie funktioniert ein Abstandsregler bzw. Regeltempomat? - MeinAuto.de
[2] Intelligent Speed Assistance (ISA) | ETSC

Electronic Horizon



Source: Continental Corp.

Electronic Horizon

Example: Continental eHorizon[1]

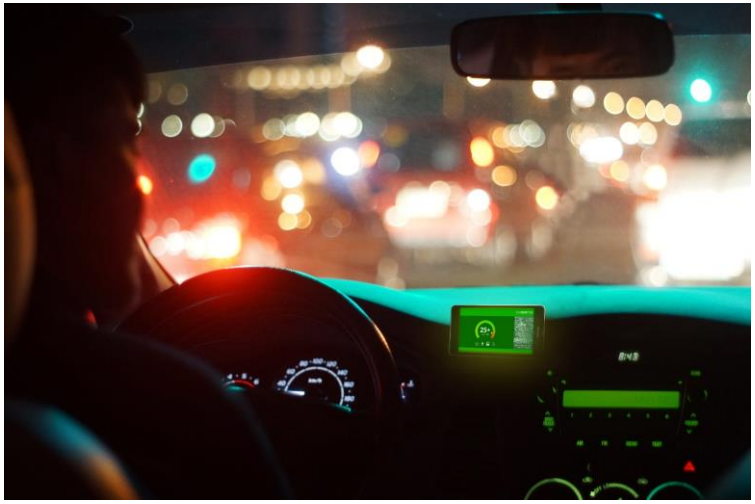
- With the electronic Horizon connected vehicles get the ability to see the road ahead - beyond its sensor vision and around the corner.
- to increase driver safety, comfort, efficiency and environmental sustainability (supporting the objectives of both the automotive industry and cities)

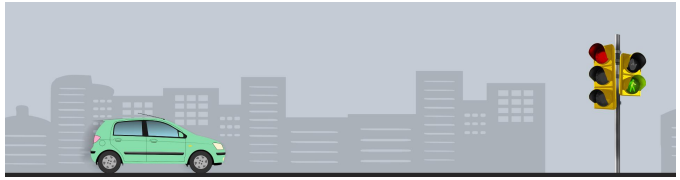
TLA – Traffic Light Assistant

- Based on predictions of traffic signal changes
- Based o industry standards SPaT / MAP[2]
- Green Light Optimal Speed Advisory Service

[1] Continental Mobility Services (continental-mobility-services.com)
[2] https://amsterdamgroup.mett.nl/downloads/handlerdownloadfiles.ashx?idnv=500795

[ui!] ECOMAT





Signal prediction with machine learning models based on real-time traffic computer data

Individual speed recommendations and additional information when holding as an APP

Compatible with SPaT / MAP messages for the back ends of the OEMs

SPaT / MAP

Signal Phase and Timing (SPaT)

Refers to communications associated with the operations of signalized intersections. The major components associated with a SPaT application are roadside equipment (RSE) and onboard equipment (OBE). A SPaT-formatted message can be used to convey the current status of a signal at an intersection.

Generally used in conjunction with Map Data (MAP) which describes the physical geometry of one or more intersections.

SPaT Challenges

Fixed time control

- Gives a pre-set green time to each movement in the intersection and use a pre-set cycle time.
- This makes it is easy to predict the signal state for a vehicle approaching in a certain direction.

Traffic-actuated or adaptive control

- Can alter the green time for each movement either within a fixed cycle length or with a changing cycle length.
- Uncertainty of prediction:
  - Fixed time signals with callable/skippable left turn phases
  - Fully actuated or semi-actuated signals –
  - Pre-emption (emergency response vehicles, Telematics Service Provider, rail, Light Rail Transit)
  - Adaptive traffic systems

Dependent on the traffic signal management philosophy, the SPaT information will be **definitive** with fixed time systems but only **indicative** with adaptive systems.

Source: Toronot, CA @ ITS Canada 2018

Speed too high – car must stop
Ecomat recommends 35 km/h

Car will have green phase
Ecomat predicts green light at given speed