Elektrobit

EB TechPaper *i*

Electronic horizon

Flexible implementation of predictive driver assistance features

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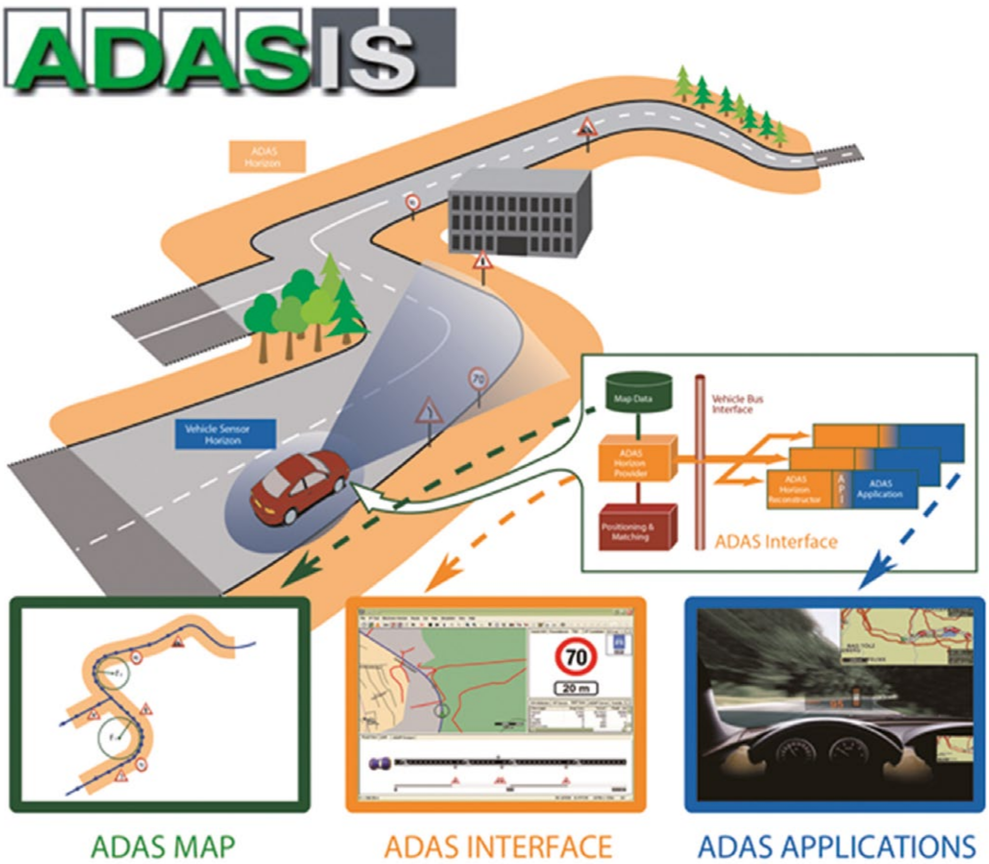
1 Introduction

Digital maps and navigation systems are not only a great assistance for the driver himself. An increasing number of vehicle functions in the domains of energy efficiency, safety and comfort, called ADAS (Advanced Driver Assistance Systems), use information about the driving route and its environment from the digital maps. The map data thereby dispose of a much greater range and complete the information provided by the usual radar, video and ultrasound sensors. For example, digital maps can provide the topography and curvature of the route ahead over several kilometres in order to efficiently control engine and gearbox.

This so-called electronic horizon provides the developer with the possibility of looking "around the corner", among others. The camera installed behind the windshield for traffic sign recognition can only register objects in the field of view of the vehicle. If however, the driver wants to turn at the intersection, indicating this with his turn lights, the maximum admissible speed after the turn may be determined from the map data before the camera even has the opportunity to register the relevant sign.

1.1 Standardization

The first implementations still use proprietary protocols in order to send ADAS horizon information from the digital map to the acting functions distributed throughout the vehicle. This however is time-intensive, prone to errors and more expensive than a standard that is already used in several application cases. Therefore, the ADASIS forum (www.ertico.com/adasisforum) decided early on to create a common protocol and interface specification. Vehicle manufacturers, control device suppliers, navigation and map specialists as well as software companies work together in order to create a specification along with its reference implementation that can cover the constantly progressing requirements.



The ADASIS forum specifies a protocol for the ADAS horizon (Source: ADASIS forum)

The „Advanced Driver Assistance Interface Specification“ (ADASIS) ensures that the various components that are required to generate and use a reliable electronic horizon work together without problems. In modern vehicles, the map data are used by more than ten different functions. These functions run in various control devices and have very different requirements to the electronic horizon. An energy saving function for example requires a longterm view with inclinations, drops and intersections, whereas a predictive curve light only deals with the road radius within a few meters from the vehicle.

1.2 Architecture

Typically, the navigation system supplies data for the electronic horizon. Starting at the current position, the „Horizon Provider“ creates a tree structure using the route and the side roads. If the vehicle moves forward, the branches "grow" correspondingly. Data from the past are deleted. The modifications are sent to the various control devices in the vehicle and used in the „Horizon Reconstructor“in order to update the local data structure. The function, for example curve warning, then collects the relevant and constantly up-to-date data in the control device.

The electronic horizon improves several driver assistance functions

One or several functions using the digital map data may exist within a control device. If several algorithms use the electronic horizon, the different requirements need to be carefully matched in order to limit the memory requirements. In particular, when existing control devices need to work with data from the electronic horizon in the future, great attention needs to be paid to the RAM demand.

1.3 Application cases

The examples listed in the following are only a small excerpt from the multiple possibilities for improving or even implementing new driver-supporting functions. Further development beyond the static map data will extend the application spectrum in the future, using dynamic content.

Dynamic data extend the electronic horizon for new applications

Functions that use map data in the form of an electronic horizon can be divided into three groups. The first group encompasses driver assistance functions that already do their job with the help of sensors, but which can improve their function using the map data.

The second group contains functions that already exist, but for which the sensors can be replaced by the data from the navigation map. The third group contains functions which cannot be implemented without map data.

1.3.1 Improve existing functions

A series of classic driver assisting functions can be improved with the help of map data. The reason for this is usually the greater range of the electronic horizon when compared to radar, video, ultrasound or lidar sensors. For example, an ACC (Adaptive Cruise Control) system can be improved with information from the map. Information about the route layout, highway on-ramp and exit and roundabout traffic contribute to a better evaluation of the radar signals.

Similarly, the fusion of street signs recognized by a camera with data from the navigation map leads to the possibility of permanently displaying the current applicable speed limit in real time.

1.3.2 Map data as sensor replacement

For some driver assistance and comfort functions, there is the possibility of replacing the sensor by using map data. This can provide two benefits at once, as exemplified by the curve lights: If the steering wheel angle is the only input value for the movement of the lights, the adaptation of the light cone to the route shape actually comes too late. Using the geometry information from the electronic horizon, the curve light can illuminate into the turn. The driver or vehicle therefore follows the light cone. The difference is particularly visible in S-curves. The electronic horizon therefore improves the function of the curve light and simultaneously removes the dependence on the steering wheel angle sensor.

1.3.3 New functions

A series of interesting vehicle functions can only be implemented once information from the digital map is available. The necessary data for algorithms cannot be readily made available by conventional sensors (video, radar, lidar, ultrasound).

Especially driver assisting functions that optimize the energy consumption are dependent on a long-term prediction of the route. The first systems in use provide notable fuel saving thanks to information on the topography, turns, intersections, etc.

Heavy vehicles such as trucks and buses profit most from this information. Due to their large weight, small deviations of a few km/h from the nominal speed already have measurable impacts on the fuel consumption. Here, the integration of an additional module that influences torque and gear selection based on the electronic horizon can have effects that amortise the cost in less than two years, depending on the application of the vehicle.

A digital map is also a basic prerequisite for automatic driving. However, this map should be much more precise as the currently available precision of one meter: Map data for automatic driving should display precisions down to a few centimetres. Furthermore, more information about the individual driving lanes, constructive divides, markings as well as footpaths, lights, signs, etc. is required.

A further requirement is the immediate availability of map updates. For example, newly build roundabouts should be included in the map data and immediately be available as an update in the vehicle. This makes it clear that automatic vehicles should receive map updates via a mobile internet connection in real time. Updates every few months via DVD or SD card are no longer sufficient.

The bandwidth of the application cases for the electronic horizon is enormous. The spectrum reaches from simple warning and comfort functions up to complex and safety-critical applications such as automatic driving, via energy saving functions that "smoothly" intervene in the work flow. The development of these systems is a challenge for the developers and requires specialized software tools.

The ideal tool chain covers the entire spectrum from simple up to highly complex driver assistance functions and is thereby both a basis for research and development projects as well as for serial production projects. Software modules and tests could then be continuously developed and optimized.

2 Software modules and development tools

2.1 Development environment for driver assistance systems

The development of driver assistance systems poses challenging requirements for the tool environment. It should provide realistic results in simulation environments, allow for prototype implementations in test vehicles and monitor them or evaluate them at the same time. Furthermore, the tool environment in the test vehicle should be capable or recording all relevant data with time stamps and be capable of replaying feeding them accordingly, in order to allow for evaluation of improvements to the software modules or to entire components or systems (HiL).

A very widespread development environment for driver assistance systems is EB Assist ADTF. It fulfils the requirements listed above, is easy to combine with other development tools and can be extended for special tasks using tool boxes. Using EB Assist ADTF, a first prototype implementation of a new function can be created directly at your desk. Input signals are either generated or retrieved from old measurements. The results of the algorithm or the relevant intermediary data may be represented with the help of various display modules, in the form of graphs or prototypes of the display as it is to be implemented in the vehicle in the future.

In the next step, the new function is to be brought into a test vehicle on the road. For this, it is most of the time sufficient to install EB Assist ADTF on a car PC in order to transfer the functions from the desktop PC. Alternately, the development notebook with the corresponding interface cards (CAN, FlexRay, Video, ...) can be used for the first operating tests. Now the algorithm can be evaluated in real time conditions. During the test drives, the car PC records all vehicle buses, outputs of the function such as for example reference video and GPS signals. This allows for a subsequent detailed evaluation of the test drive at the office. Aside from the evaluation, these data serve the purpose of stimulus and reference for improvements and optimization in the next development steps.

2.2 Toolboxes

Two tool boxes that extend EB Assist ADTF for comprehensive support are available for the development of driver assistance functions with electronic horizon. Both tool boxes implement the ADASISv2 standard. Furthermore, there are variations with proprietary electronic horizon that do not follow the ADASIS standard.

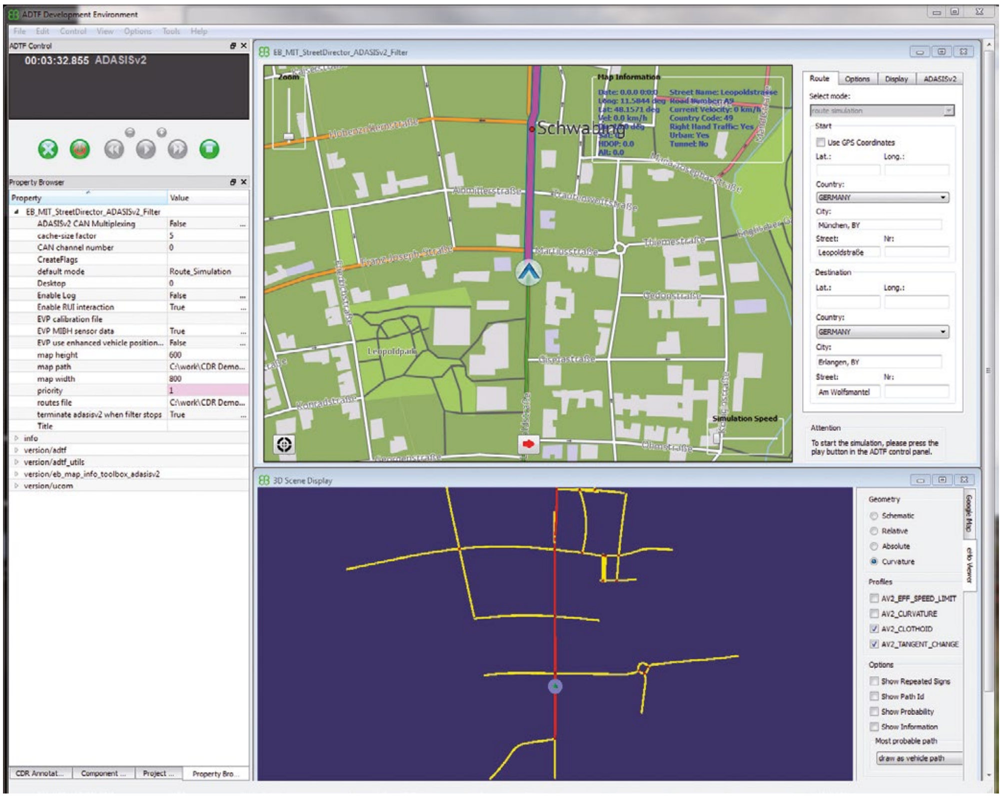
2.2.1 Horizon Provider Toolbox

The Horizon Provider Toolbox contains a complete series-tested navigation, the EB street director by Elektrobit. The tool box can output an electronic horizon along the planned route in simulation mode, after input of starting point and destination. The developer can also use real or recorded GPS data in order to control the navigation. The output of the Horizon Provider Toolbox can either be used within the development environment EB Assist ADTF or the data are forwarded to other systems such as for example MATLAB/Simulink. Since EB Assist ADTF can output the electronic horizon directly on the CAN bus, there is the possibility to connect hardware such as for example the prototype platform MicroAutoBox from dSPACE, evaluation boards from semiconductor manufacturers or eelctronic control units (ECUs).

2.2.2 Horizon Reconstructor Toolbox

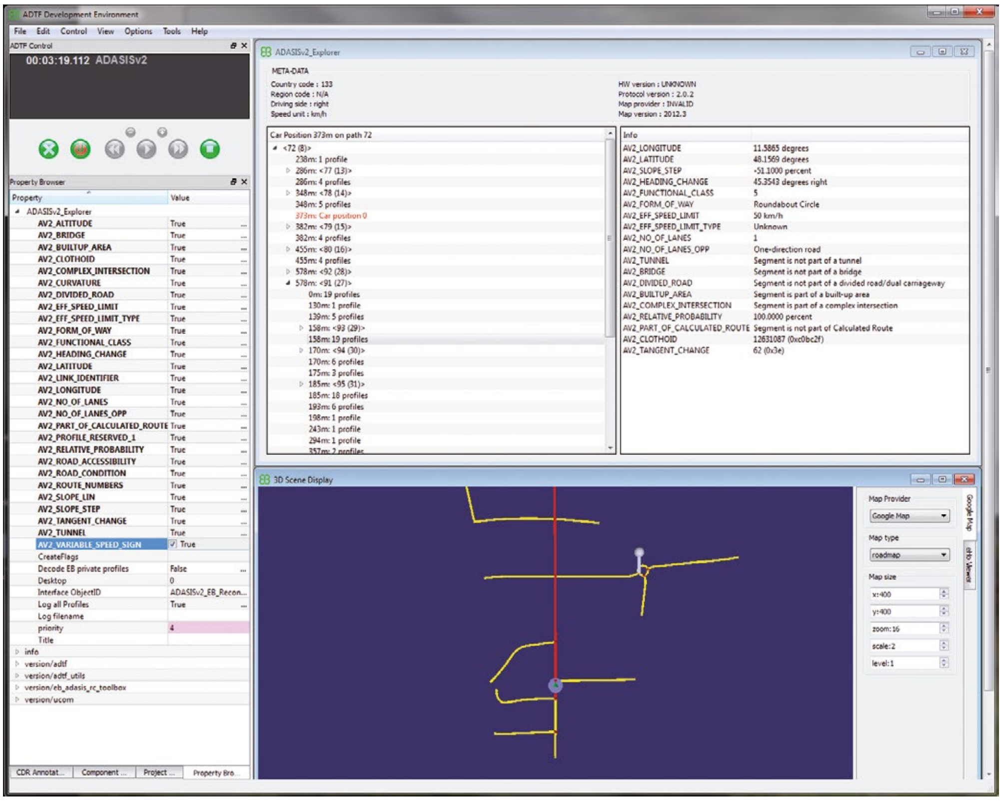
The Horizon Reconstructor Toolbox is the counterpart to the Provider Toolbox. It contains the Reconstructor, that continuously incorporates the incoming updates of the electronic horizon in the local data structure. At the same time, the Reconstructor deletes data that lie further back than the predefined distance behind the current vehicle position.

Further components of the Horizon Reconstructor Toolbox serve the purpose of analysis and visualization of the electronic horizon. If a function, such as for example a curve speed warning, does not react as expected, the developer can analyse and verify the data from the electronic horizon to see whether the faulty behaviour can be traced back to the input data. If this does not apply, the temporal behaviour is analysed before the algorithm itself finally comes to be questioned.



The Horizon Viewer (in the picture below) visualized the received geometry data

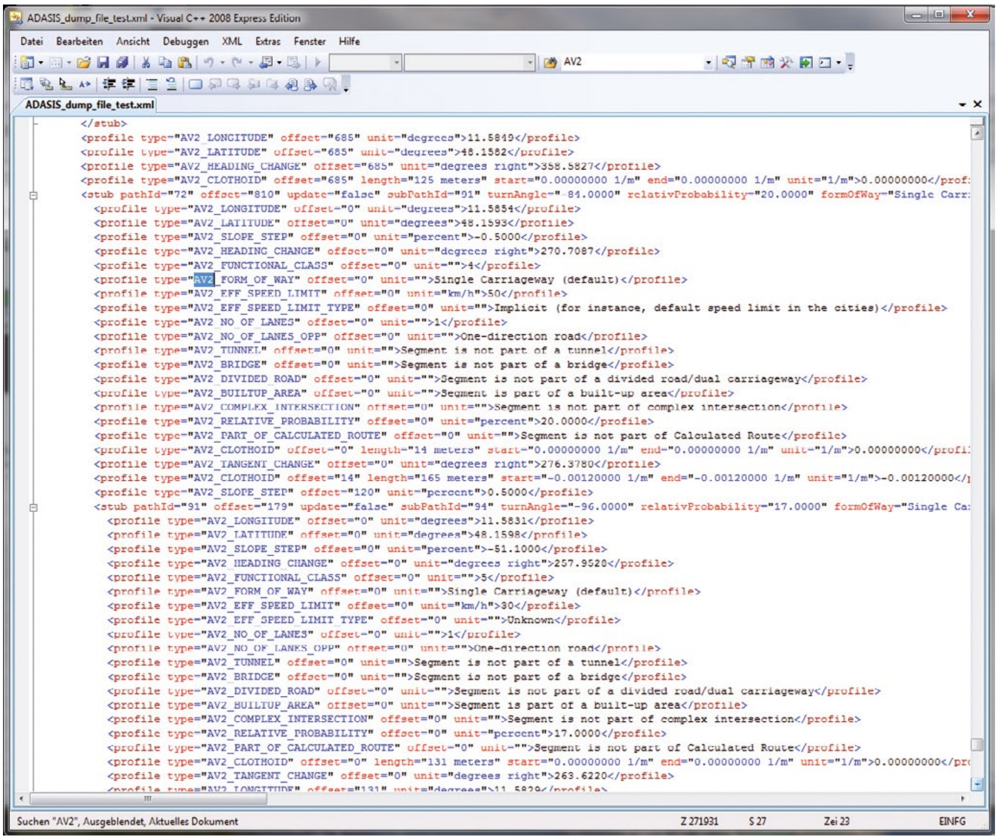
The Horizon Viewer is based on the EB Assist ADTF 3D Scene Display and visualises the roadgeometry data from electronic horizon. The current route or, in the case of inactive routing, the so-called „Most Probable Path“ are thereby highlighted in colour. If the Horizon Viewer is running during a test drive, the developer can follow how the electronic horizon continuously is extended in the direction of driving and how the data lying further back are deleted. If the Horizon Provider for example does not provide any or only very little data, this becomes immediately visible in the Horizon Viewer. With an active internet connection, the additionally displayable satellite map makes further information for the evaluation of the system behaviour available. Detailed information about the data received from the Horizon Reconstructor are represented in a clear fashion by the Horizon Explorer. The data can be folded in and out at the various positions using a mouse click. Irrelevant data can be deactivated in order to highlight the essential.



The Horizon Explorer allows for a detailed analysis of the data that are received by the Horizon Reconstructor.

Horizon Viewer and Horizon Explorer are linked. If the developer selects data in the text display, a marking needle appears at the corresponding position in the Horizon Viewer. Inversely, a double click on a position in the route highlights the corresponding data in the Horizon Explorer. The developer is thereby best supported during the analysis.

The Horizon Dumper writes the entire content of the electronic horizon in an XML file, for example to compare between test drives. The developer thereby has the possibility of precisely analysing the basic data in the case of differing behaviours of an algorithm on the same route. Deviations may be caused by variations in the positioning or the driven speeds.



A complete display of the received data is saved in XML format by the Horizon Dumper.

2.2.3 MATLAB/Simulink

For the model-based development of a function with data from the electronic horizon in MATLAB/Simulink, the connection can occur via Ethernet or CAN interface. The Horizon Provider thereby runs in EB Assist ADTF and sends the data of the electronic horizon to the corresponding interface. For MATLAB/Simulink, the Horizon Reconstructor is available as a block set.

2.2.4 dSPACE MicroAutoBox

After a thorough simulation in the office, the new function needs to be tested under real conditions in a test vehicle. For this, the model from MATLAB/Simulink can be ported out onto a prototyping platform such as for example the MicroAutoBox from dSPACE. The Horizon Reconstructor that runs in the MicroAutoBox for prototyping is based on the same source code as the Reconstructor in EB Assist ADTF. The Horizon Reconstructor for the series production control device is available from the same code base.

2.2.5 Car Data Recorder Toolbox

The control of recordings and the visualization of data during test drives can efficiently and comfortably occur with an iPad. The Car Data Recorder Toolbox for EB Assist ADTF represents data from the testing environment via WLAN on the high-resolution retina-display very well.

Instead of a fixed installed monitor and a keyboard, for example trigger conditions for the recording can be elegantly adjusted using the iPad, even from outside the vehicle.

Clear representation of the electronic horizon, the map view and the vehicle data on an iPad

2.3 Software modules

After a successful pre-development phase with simulations and prototype implementations, the integration of the new function in the control device is pending. For this step, it is a great advantage if the software components used in the tool boxes are available for the embedded target platform.

The mentioned Horizon Provider and Horizon Reconstructor software components ware developed and continuously optimized by EB Automotive for use in the control device. The variations for the use in the tool boxes are generated based on this tested code base. The developer thereby relies on software close to series production from the start and simultaneously has the comfort and the flexibility of a PC-supported development environment.stimulus and reference for improvements and optimization in the next development steps.

3 Conclusion

The development of attractive driver assistance functions is the most demanding task. During the development time, the requirement towards the tool environment change in accordance with the intermediary targets. While research lays more value on flexibility, the reliability of the software is more important for series development.

With the Horizon Provider and Reconstructor tool boxes, extensions that comprehensively operate the theme of electronic horizons from the PC environment to the micro-controller based control devices are available. In this manner, the developer team can focus on the design and implementation of the driver assistance function and rely on series-tested components and does not need to provide efforts for the acquisition of data from the digital map.

The subject of "electronic horizon" is receiving an additional big push with the advent of automatic driving. In addition to highly precise and detailed map material, dynamic contents and real-time information flow via the cloud play important roles. Only then does it become possible to flexibly react to obstructions on the route or traffic jams, so that the drive can be executed in a efficient and safe manner without driver intervention. The tools for the development and validation of these systems need to adapt to the new requirements and grow with them. EB Assist ADTF and the Horizon toolboxes have proven that they flexibly adapt to new task areas and allow the developers to efficiently develop modern driver assistance systems in several projects from various car manufacturers and suppliers.

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About EB Automotive

EB Automotive is recognized internationally as one of the most important suppliers of embedded software solutions in the automotive industry. In addition to the development of products, EB Automotive also specializes in services and consulting for the automotive industry, supplying implementations of software solutions for a broad range of AUTOSAR ECUs, functional safety, infotainment, navigation, HMI and driver assistance systems. EB continues to invest in feature integration and development tools ensuring in-vehicle devices ship in volume earlier and arrive quickly to market.

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