“eCoMove – EfficientDynamics Approach to Sustainable CO2 Reduction”

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Abstract

Climate change brought about by industrial influences is a matter of fact and requires urgent action by everyone, including the EU and the automotive industry. No other EU project than the “eCoMove” project claimed to reduced fuel consumption and CO2 emissions of its range for about 20% with new green driving technologies.

Focus is pointed on the eCoMove project that offers BMW, NAVTEQ and partners the opportunity to share views, requirements and concepts regarding the field of green driving to reduce CO2 emissions. And also it gives the opportunity to support map database suppliers in developing new methods of dynamic data capturing, dynamic extending data formats, and obtaining feedback through real-life experience with the BMW prototype application eCoAssist. The nature of this research project dictates the need for deep experience in Car2X communication services for green in-vehicle applications, predictive efficiency driving strategies with optimized longitudinal control as well as multimodale and perspective HMI functionalities. BMW will demonstrate the complete chain of the eCoAssist application to reduce CO2 emissions. The results of eCoMove will be taken into account for the development of the EfficientDynamics and ConnectedDrive strategy that includes:

- Engine start stop function and intelligent energy management
- Brake energy regeneration and gear shift indicator
- Improved engines and power train
- Learning electronic horizon
- Predictive efficiency driving strategies with optimized longitudinal control
- Multimodale and perspective HMI functionalities
- Intelligent ACC with special control strategies and Car2X communication

to achieve the eCoMove target of 20% of fuel reduction.

Keywords: EfficientDynamics, ConnectedDrive, CO2 Emission, eCoMove and eCoAssist, Car2X Communication

The complete system***, eCoAssist***, based on on-board systems, increases vehicles' intelligence and contributes to a ***safer*** and more ***energy-efficient driving*** as well as reducing ***CO2 emissions.***.

Optimality of driving depends of many factors, and eCoAssist will use two previously developed BMW applications: the BMW ***Dynamic Pass Predictor*** (DPP) and the BMW ***Adaptive Speed Recommendation*** (ASR). ASR and DPP are safety-oriented applications; those two existing systems will be improved to offer even a higher degree of accident prevention through improved driver-information, driver-warning strategies and an improved actuation via the improved MAPS&ADAS protocol, the visibility sensing system, as well with the integration of the independent ACC system.

Additional module***, eCoDriver***, will complement safety aspects of ASR and DPP. Using speed recommendations calculated by ASR and DPP, special green acceleration and braking strategies, as well by using additional dynamic car data such as current gear and RPM, the optimal driving strategy will be calculated and presented with a special HMI to the driver.

To ensure driver has chosen most efficient route in the first place, system also includes innovative routing algorithm that, taking in account dynamic vehicle parameters, driver preferences and digital map data, calculates most environment-friendly way to the destination. This module is called ***eCoRouter*** and it also included route guidance function.

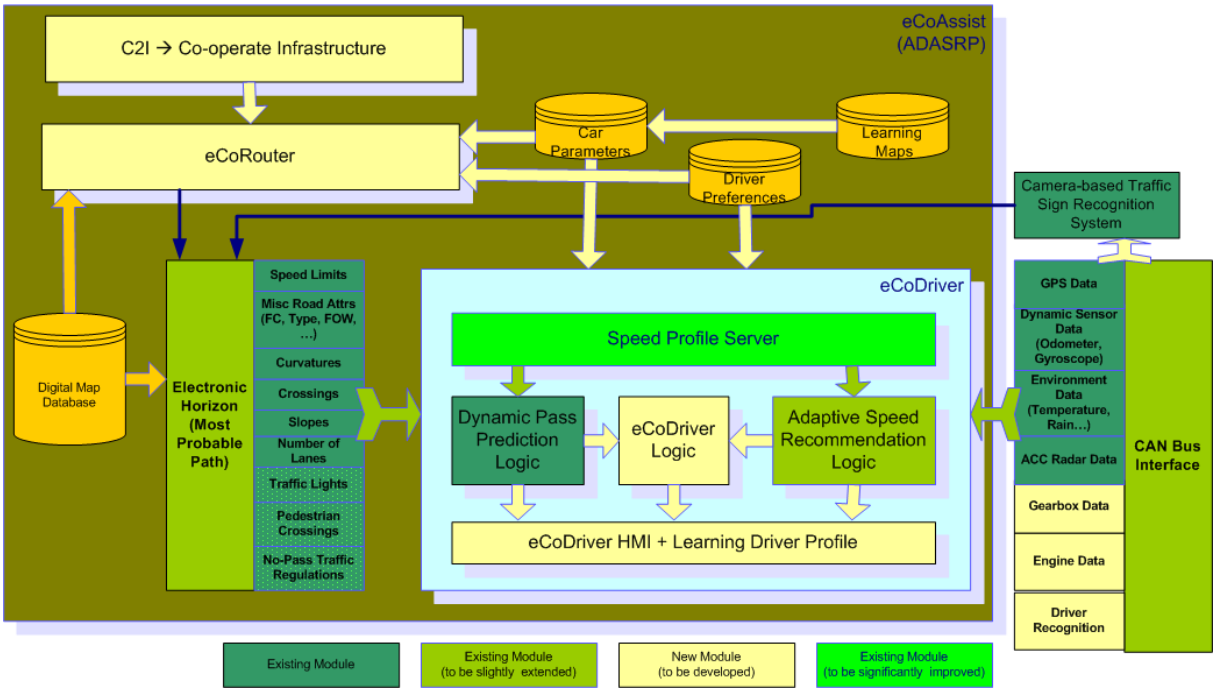

Figure 1 eCoAssist and eCoDriver Architecture

NAVTEQ ADAS Research Platform

The system prototype will be implemented using well-known NAVTEQ ***ADAS Research Platform*** framework. ADASRP includes the following components:

- *Digital Map Database*;
- *Electronic Horizon*;
- *CAN Bus Interface* (with special BMW module);
- *Vehicle Positioning*;
- *Extensible User Interface* including BMW Head-Up Display (HuD) and Central Information Display (CID) support.

Speed Profile Server

Speed Profile Server (SPS) is module that calculates maximum speed along the Most-Probable-Path of the car based on the static map data as well on dynamic car information. Camera-based Traffic Sign Recognition will provide additional data that will increase quality of SPS output that is in use both by Dynamic Pass Predictor and Adaptive Speed Recommendation modules.

Dynamic Pass Prediction

Based on road geometry and other attributes in digital navigation maps as well as actual driving dynamic parameters ***Dynamic Pass Predictor*** informs the driver about road sections that are not safe for overtaking. In the sense of the DPP concept the driver will get knowledge about roads ahead even when he is driving in unfamiliar areas.

Figure 2 BMW Test vehicle with eCoAssist and DPP navigation display

As you can see in Figure 2, e.g., the vehicle is driving with DPP on road sections that are not safe for overtaking (orange sections). So, the DPP will adapt the speed to vehicles ahead that the driver is supported with a safe speed on the stretch of the road the driver is currently driving. To provide this helpful support, the DPP application with a given graphic in the instrument cluster in the cockpit (HuD and navigation display on CID) presenting the sections of not safe for overtaking.

Adaptive Speed Recommendation

The Adaptive Speed Recommendation system acts as a personal co-driver. Country roads hold the greatest danger for road users. It may be the case that only 27 % of all accidents occur on these routes, but most of them are extremely serious. Many such accidents can be attributed to overestimating one's own driving skills or misjudging physical limits such as grip levels and curve radii. BMW Group Research and Technology in cooperation with NAVTEQ has developed the speed recommendation system to help drivers think ahead at the wheel. This assistance technology uses the navigation system to provide information, irrespective of individual speed, on the nature of an upcoming curve, crossing or legal speed limit. This extended horizon makes it easy for the driver to prepare himself in advance for the characteristics of the road ahead – and that makes the driving experience safer (see Fig. 3).

Figure 3: BMW Test vehicle with eCoAssist and ASR navigation display

eCoDriver Assistant

To highlight the innovative aspects of this new application the eCoDriver Assistant will combine the two ADAS applications DPP and ASR. It will further combine the data from the digital map (curves, crossings, relevant traffic signs, slopes) with integrated vehicle parameters (given by the vehicle sensors via CAN, e.g., gear-shifting, wipers, turn signal), and ACC functionalities (e.g., distance and speed of vehicle in front) to support the driver while driving with a improved Electronic Horizon. The Electronic horizon allows anticipatory driving.

Overtaking and the curve speed with a better knowledge of the environment, i.e., long range visibility provided by the map data and visibility range provided by the visibility sensor and road side data will lead to reduce the heavy fuel consumption and therefore leads to a safer, greener and smarter driving

This function will help the driver above all on roads where it is not safe for overtaking especially or to have a high curve speed on longer distances, on rural and curvy roads, at unknown locations, thus ensuring that the driver is supported in such cases, especially by

using special green acceleration and braking strategies. The eCoAssist function will receive its information on the route from the road side information channel and from the navigation system, which also comprises information about an improved electronic horizon as well as a prediction to support “eCoDriver” (see Fig. 4).

Figure 4: BMW eCoAssist and eCoDriver with a modern electronic horizon

eCoRouter module

The eCoRouter module will combine the digital Map database content with traffic information from the infrastructure, dynamic vehicle parameters and driver profile information to calculate the route that minimizes fuel consumption. This ecological route will be proposed as an additional option to the classical fastest and shortest route alternatives offered by the navigation device. Route guidance will be displayed together with the eCoDriver Assistant recommendations. Using the information provided by the eCoDriver Assistant and dynamic vehicle parameters analysed by the system during the trip to the destination, the eCoRouter module will have the ability to learn in order to subsequently provide routes better adapted to the driver and vehicle.

Traffic directly affects expected speed which in turn can be related to fuel consumption. The average speed at which a link can be traversed will be inferred from NAVTEQ Traffic Pattern data, if available at the test site location, together with real-time traffic data received from the Infrastructure. Physical characteristics of the road as well as traffic regulation features potentially generating stop and go situations also have a strong impact on the fuel consumption. Thus, attributes like slope, curvature, traffic lights, stop signs and special speed limit conditions (speed bumps) should be taken into consideration by the routing algorithm.

Using the continuous consumption and driving monitoring functionality of the ecoDriving Assistant, the eCoRouter module will be able to associate an ecological weight to links in the

map. The learning map will be enriched with high and low consumption areas thus continuously growing to become a map adapted to the drivers behaviour and improvements. The driver will be presented a consumption and CO2 assessment at the end of his trip to further support the eCoDriving Assistant.
If the routing is enabled, the calculated route will be taken as the most probable path in the electronic horizon used by the eCoDriving Assistant.

Green HMI Concepts

Different HMI output devices for the ***eCoAssist*** and ***eCoDriver*** are evaluated regarding their potential to convey information on efficient and anticipative driving to the driver (e.g., acceleration, deceleration, and gear-shift). The HMI should act as an eco-driving coach for the driver. Output devices exploiting different modalities are compared standalone and in combinations. Examples include displays (cluster, TFT, head-up display) haptic feedback through the seat and pedals as well as sound. Premises are to integrate information and avoid information overflow but to provide the driver with intuitive ambient information on the most efficient driving style in the given situation. The selection will be based on rapid prototyping and evaluation in the driving simulator or test track. The information under presentation concepts will be designed following the current human-factors requirements for in-vehicle systems.

Conclusion

The installation of eCoAssist and eCoDriver will be done in a common work together with partners (BMW, NAVTEQ, ERTICO et al.) which includes the development and introducing this wide range of improvements in green driving technologies. The Partners are making a significant contribution to the improvement of mobility and the further fuel reduction and reduction of CO2 emissions over and above the development of new automotive technologies.