# The development of additional services using Vehicle-to-Person (V2P) interface

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**Abstract.** The article discusses the possibility of using Vehicle-to-Person (V2P) interface for the organization of additional services, including services of intelligent transport systems (ITS), on wheeled transport in use. The example of external tire-pressure monitoring system (TPMS) development, implemented in user smartphone is introduced.
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**Keywords:** Vehicle, Vehicle-to-Person interface, V2P, Intelligent Transport Systems, ITS, CAN bus, tire-pressure monitoring system, TPMS

## Introduction

The automotive electronics improvement determines the current trends in the development of auto industry with respect to satiety the wheeled transport with information technology and additional services. The vehicle is no longer a single vehicle and starts to become integrated into starting to be integrated into the information transport medium [1], in particular into the network of the intelligent transport systems (ITS) [2, 3].

Currently, the availability of modern information technologies and services is becoming increasingly important competitive advantage of a new vehicle. However, the motor-vehicle manufacturers are little interested in the issue of equipping the vehicles that are already in operation with new services, but this issue is in the interests of the consumers, and it means that it is of current importance and urgent.

## The use of smartphones as external vehicle ECU

According to the researches carried out by eMarketer, the number of active users of smartphones by the beginning of 2015 will amount approximately 1.7 billion people. In Russia, the percentage of smartphone users has already made up more than 40% of the total number of subscribers to cellular networks and the positive dynamics will continue in the future. Against this background, the motor-car manufacturers have been offering the content communication technologies of smartphones with onboard multimedia systems of vehicles for several years, for example, the streaming audio function of music over Bluetooth interface and others. And also now MirrorLink project is actively under development in respect to Smartphone application management through vehicle multimedia interface. It should be noted that the above-mentioned technologies relate to infotainment and as a matter of fact they extend the functionality of the vehicle multimedia systems.

We propose to use the software and hardware platform of the smartphones for the organization of the services functioning providing the increase of active, environmental, anti-theft, post-crash safety of vehicles which are in use now and were not originally equipped with these systems. In fact, we suggest to use smartphones as external electronic control units (ECU) of the wheeled transport. The smartphone's schematic wiring diagram to the on-board wheeled transport network (WT) is shown in Figure 1.

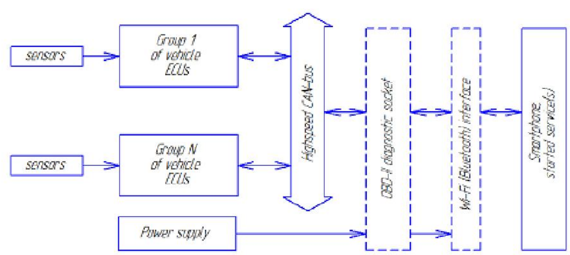


**Fig. 1. The smartphone's wiring diagram to the on-board WT network**

Either standard device, for example, ELM327 (fig. 2) or any more efficient device or a device, specially designed by motor-car manufacturer (currently there are no such devices available) can be used as Wi-Fi (Bluetooth) interface between the data link connector of the vehicle and smartphone. In the article the possibility of data acquisition from CAN bus as the most common one is considered.

In the proposed concept the proprietary software is running in the smartphone, which, interacting via the wireless interface (in this case via AT commands) with the device connected to the data link connector of the vehicle, gets the values of sensors reading installed in the vehicle. Next, by the algorithms, implemented in the software application of the smartphone, the calculation data or monitoring results are displayed on the phone's screen with the possibility of sound notifications. When using MirrorLink technology the results of the running application in the smartphone can be displayed on the vehicle multimedia systems screen.

**Fig. 2. Example of connecting the device with chip ELM327 to the vehicle**

When implementing of the proposed concept the following systems and services can be developed:
- tire pressure monitoring system (TPMS);
- remote diagnostics system;
- after sales services (notification of the technical inspection schedule, record for the repairs, etc.);
- "data recorder", that is, continuous recording of the parameters and conditions of the vehicle movement, as well as of the control actions on the part of the driver into the memory of the Smartphone or "cloud service";
- service of green driving, i.e. issuing the recommendations to the driver as for vehicle operation with the minimum fuel consumption and wear of the components and assemblies of WT;
- anti-theft system, when the driver's smartphone acts as "anti-theft mark";
- analogue of the Urgent Response System in the emergency situations (“ERA GLONASS” in Russia, "eCall" in Europe);
- hybrid navigation [4];
- and others.

**Features of the data acquisition from the onboard CAN bus of the vehicle**

Essentially, the data from CAN bus of any means of transport can be obtained in two ways [5]:
1) reading in "passive" mode all messages that pass via the bus and filtering the necessary messages according identifiers, at the same time the additional load on CAN bus is created, the data acquisition takes place with maximum sampling rate, but it is necessary to have a decoding database for each vehicle, which is specially protected motor-car manufacturer intellectual property;
2) sending specific requests to the bus (in this case, diagnostic interrogations according to OBD-II standard [6, 7]) and receiving response messages. Diagnostic interrogations have a lower priority and, consequently, a lower sampling frequency of the received data, create an additional load on CAN bus and, above all, they have limited functionality. For example, for vehicles, there are no standardized queries for receiving the values of steering input angle, individual wheels speeds, etc.

On the basis of the foregoing, it follows that the first way is a priority one, but then either the motor-car manufacturers or companies directly associated with them that have access to the decoding database may develop additional services on the proposed concept.

The task of the data decoding from CAN bus (decision of the reverse engineering problem or “reverse engineering”) is technologically feasible, but the legal status of such works is not clear, in view of the peculiarities of legislation of different countries. Know-how "methods of the data decoding transmitted via CAN-bus of the transport and production machines" has been developed at Moscow State Automobile and Road Technical University (State Technical University – MADI), so we can decode the data from CAN bus of the wheeled transport. These works are carried under laboratory conditions and they are exclusively for research or educational purposes.

The second way of the data acquisition from the vehicle's lighter socket is a limited one by its nature, by any developers can deal with the creation of additional services, according to the proposed concept.

**Development of the external pressure control system in pneumatic tires**

A transport vehicle of the category M1 - Chevrolet Orlando of 2012 production year, equipped with high speed CAN bus, class “C" with a data transfer rate of 500 Kbps was selected as an object-to-be-tested. 11-bit message identifiers were applied in the network architecture. The following data have

been decoded and later they were used in the TPMS algorithms:
- linear velocity of four wheels;
- steering-wheel angle;
- the linear speed of the vehicle movement;
- throttle pedal position;
- brake pedal position.

The road tests were conducted in a real urban environments at the speeds of movement within 60 km/h, the system has been developed for the indirect determination of pressure in pneumatic tires. Individual definition of the flat tire was carried out by a combination of known "axis" and "diagonal" algorithms [8] with the introduction of amendments to the driver controlling actions [9, 10]. The program development was implemented in MatLab and with subsequent porting to a smartphone with Android OS. Interaction with vehicle on-board electronics was carried out via Wi-Fi using AT command of ELM327 chip specifying the individual protocol.

As a result of the research, the external system of the pressure in pneumatic tires indirect determination with the following characteristics was developed to test object: the definition of the flat tire in urban driving within 1 minute (10 seconds for the definition, 50 seconds for the confirmation) with the sound notification of the driver.

**The main results and conclusions**

As a result of the research:

1. The concept of the Vehicle-to-Person interface for the introduction of additional systems and services to the wheeled transport which are in use has been developed.
2. The external system of the pressure in pneumatic tires indirect determination running in the user's smartphone has been developed.

The development of the proposed concept can contribute to the growth of the market of the additional services and systems for the wheeled transport in use.

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