III INTERNATIONAL CONFERENCE
TRANSPORT SYSTEMS TELEMATICS TST`03

ZESZYTY NAUKOWE
POLITECHNIKI ŚLĄSKIEJ 2003
TRANSPORT z.51, nr kol. 1608

*Intelligent Transportation Systems,*
*intelligent car,*
*telematic solutions in road transport*

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# AN INTELLIGENT VEHICLE

The paper has presented technological solutions in an intelligent car, navigation and vehicle positioning systems, systems for identification objects on the road, cooperation between a human being and a vehicle. The author has described fundamental solutions, which are currently used in cars and are also in the phase of advanced research.

# INTELIGENTNY POJAZD

Referat prezentuje najnowsze rozwiązania techniczne, które znalazły zastosowanie w pojeździe inteligentnym, systemy nawigacji i identyfikacji pojazdu, systemy rozpoznawania obiektów na drodze czy układy wspomagające współdziałanie człowieka z pojazdem. Autor opisał kilka kluczowych rozwiązań, które są obecnie stosowane w samochodach osobowych, ale także te, które są na etapie zaawansowanych badań.

## 1. INTRODUCTION

At present telematic solutions are used in road transport. Transport telematics consists of the following aspects:

- transmission of information to and from a vehicle (telecommunication),
- processing of information (Information Technology),
- information usage for safe transport and effective usage of already existing technologies' solutions.

Such changeable light boards as navigation systems, the Internet, mobile networks are just few examples of telematics usage in road transport. One of the examples of telematics, IT and telecommunication solutions'usage is an intelligent vehicle. There have been continuous works on an intelligent vehicle construction carried out in the world. However, no precise definition of the vehicle has been created so far. Car producers from Stuttgart in Germany are proposing the following definition „an intelligent car is such a vehicle, which due to IT, telecommunication and telematics' solutions, creates one system that aims at increase of

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usage comfort, improvement of passive and active safety and provision of unrestricted access to information. Due to state-of-the-art. technologies' usage such vehicles gain features of intelligence such as ability of perceiving, understanding and adaptation to chosen transport conditions.

Implementation of an intelligent car heads towards:

- increasing active safety leading to decreasing road collisions,
- increasing passive safety aiming at easing results of accidents,
- increasing automatic control of various elements,
- easing driver's effort through installation of different systems supporting their driving,
- fuel consumption and fumes emission decreasing in the places of high road transport concentration,
- provision of vast access to up-to-date information, swiftly transmitted to the concerned parties,
- immediate charge provision for road infrastructure usage.

In many cases, the implemented devices fulfill requirements of more than one direction. Equipping a driver in systems exempting them from some activities that they would have to perform, for example a joystick (replacing a driver, a steering wheel, acceleration pedal) improve a vehicle's performance, ease a driver's effort and influence improvement of active safety, especially in case of sudden braking.

In a traditional vehicle the time of reaction until the moment of functioning of the brakes varies usually between 0,8 to 1 seconds. Due to employing computer systems and a joystick the time of the driver's reaction should become considerably limited. Apart from that, the distance to be covered by nervous impulses from the brain to the hand is shorter than from the brain to the foot. Joystick needs not to be moved by a single inch while braking. The sensors immediately detect the pressure and its force and the computer activates the brakes. At each of those stages we economise on time, which results in shortening of the braking distance, which when the speed doubles - increases by four times. Similar situation takes place while taking a sudden turn: the steering mechanism of passenger cars with support, which operates infallibly at small speeds, increases the resistance together with the increase of the speed.

The implication is that even the slightest turn of the wheels requires considerable movement of the steering wheel. It cannot be different otherwise the steering wheel would not be able to control the car at high speeds. In case of using a joystick, the reaction is much faster, because its maximum inclination is fairly small. Additionally, the computer automatically makes sure that the turn is most efficient without allowing for losing control of the car. Similarly to other navigation systems based on GPS, they enable not only a safe trip from departure point to destination but also as integrated telematic systems they provide information of the situation on the roads like traffic jams, road accidents, road works. They may serve as a tool helpful while paying the toll.

Majority of the aforementioned systems is multidirectional – the systems, however, do not let the driver off driving the car – they only support him in the field of technology, safety and lessening of his effort while driving. In order to fully achieve the goal there is also a need for automatic steering of the car. This problem is especially difficult to be solved and implemented in the conditions of city traffic where there is a high density of vehicles. On longer distances on the other hand, there are parts of roads, which might be treated as marked out (e.g. highways). It is possible to install, in such circumstances, a system of automatic vehicle guiding. It is inevitably connected with fulfilling a number of pre-conditions. Apart from the essential requirement i.e. automatic guiding along the line of the road, such system should also fulfil the prerequisites of so called active safety. This, in turn, demands form the system additional but necessary requirements like: immediate reactions to the change of situation on the road, fast flow of information from all the systems of sensors and detectors and making decisions in a situation when the driver does not start to control the car after a particular time. The system should cause automatic braking down of the vehicle and pulling out if it is possible under given circumstances. In cases when the system ceases to perform the assigned activities the driver should take over controlling the car.

The emergence of an intelligent car is supported by other telematic solutions like:

- traffic monitoring equipment (sensors, detectors, steering equipment, video detectors), television supervision devices (supervising cameras),
- weather monitoring and measuring systems (SPID),
- changeable light panels (VMS),
- systems of satellite navigation (GPS, GLONASS, and in the future ENGOS GALILEO),
- derivative systems used in navigation (DGPS, WADGPS),
- systems of radio communication (DAB, RDS-TMC),
- geographical data bases (GIS),
- bases of road data,
- electronic cards.

## 2. TECHNICAL SOLUTIONS

There is a wide usage of electronics and IT both at the project, production and construction stage in modern cars. It is vital to create new solutions with the use of telematics and IT in an intelligent car – building process. Basic electronic systems, installed in modern vehicles, are depicted in scheme 1. These systems are usually independent from each other and control only certain elements of a vehicle or its movement, without cooperation with other systems. Independence of these systems results in each device having to be served and operated by a special equipment. In order for the systems to be properly used, they functions should be connected. Connection of these systems is also associated with introduction of new steering methods, improvement of information transmission and changing of particular devices supervision structure. The CAN hub is used for this purpose. It consists of both a hub and a protocol describing the way of data transmission. The CAN's operation is based on a broadcasting system. It means that information is transmitted by one device and the other are able to receive it. As all the data sent include identification of an addressee, each of the receivers „knows" whether it has been sent to them. The CAN's hub has been constructed in such a way that the only one device, at a moment, is able to transmit information. If information should be transmitted by many devices, all of them go on stand-by, and the ones with the highest priority begin transmission. A construction of an intelligent vehicle requires finding such solutions (in its construction), which will allow to introduce more and more advanced steering devices, without hampering a driver from their use. In effect, the highest number of individual steering devices should be connected in one mechanism, in one common system, until the central system of steering and control will be built. Interconnection of elements within one system (for example executive elements with supply) is the simplest integration method. The further step would be usage of one system elements in other systems (i.e. wheels ABS speed sensors to steer ASP system). Replacement of individual systems interaction by a group interaction can be the next phase. This could work through connection of steering systems interacting with the same elements of a vehicle (for example interaction of ABS, ASR, 4WD, 4WS and ASC with a vehicle wheel)

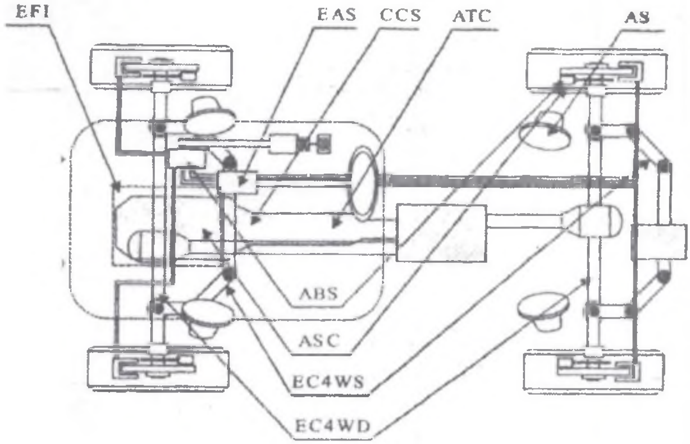


Fig.1. System of control and measurement
Steering systems of comfort providing devices and of protecting passengers during collision

EAS - *(Electronically Assisted Steering)*, EFI - *(Electronic Fuel Injection)*, ASC - *(Anti Slip Control)*, EC4WS - *(Electronically Controlled 4WS)*, ABS - układ przeciwbiokujący *(Antiblocking Braking System)*, EC4WD - *(Electronically Controlled 4WD)*, AS -*(Active Suspension)*, ATC - *(Automatic Transmission Control)*, CCS*(Cruise Control System)*

Obviously an intelligent vehicle apart from the aforementioned systems must be equipped with sensors, detectors, video cameras and other devices (see figure 2) that ensure fulfilment of stated requirements regarding comfort of usage, improvement of active and passive safety and unrestricted access to information.

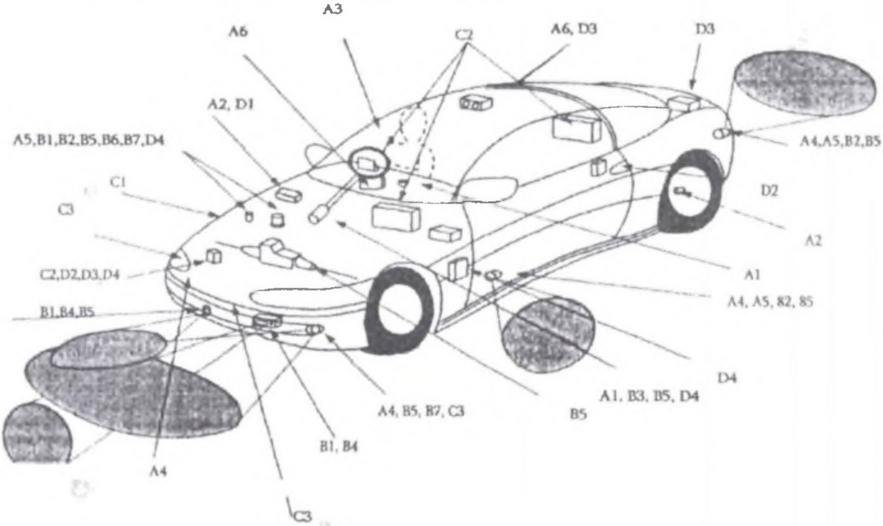


Fig.2. Intelligent vehicle – prototype solution

Table 1

Description of security systems in the movement of intelligent vehicle

| SYSTEM GROUP | SYSTEM | SENSORS ACCORDING TO THE PICTURE | NUMBER |
|---|---|---|---|
| Ensuring safety of the driving, monitoring conditions of the journey and warning against the possibility of danger | Detecting and warning against loss of concentration of the driver,<br>Warning against fall of pressure in the tyres, fire detection,<br>Creating good visibility (intelligent headlights, system of wipers and windows reacting to weather changes)<br>Warning against obstacles while night driving (system HUD)<br>Warning against being knocked over from the back (video cameras, and sensor)<br>Active navigation system | A1<br>A2<br>A3<br>A4<br>A5<br>A6 | 1<br>2<br>3<br>4<br>5<br>6 |
| Allowing to avoid accident, monitoring obstacles and warning against them, in case of necessity automatically activate the brakes and steering mechanism | Keeping distance in relation to the preceding car, radar systems,<br>Driving in one lane, preventing from sudden change of lane,<br>Warning against moving off the lane,<br>Regulating speed with regard to distance to the preceding car (ICC),<br>Avoiding collisions, automatic braking combined with steering,<br>Regulating speed while driving along a curved line and on entering intelligent traffic lights,<br>Warning against road signs of changing meaning. | B1<br>B2<br>B3<br>B4<br>B5<br>B6<br>B7 | 7<br>8<br>9<br>10<br>11<br>12<br>13 |
| Limiting results of accidents, minimising human casualties inside the vehicle and outside of it. | Absorbing energy in case of rear, side and front collisions<br>Securing passengers from the front, side and rear collision (intelligent air bags)<br>Minimising results of collisions with pedestrians – outside air bag | C 1<br>C2<br>C3 | 14<br>15<br>16 |
| Facilitating post-accident activities like evacuation of people from the vehicle and calling for help | Detecting and extinguishing fire under the bonnet and inside the vehicle,<br>Releasing the door blockade after an accident<br>Calling for medical assistance after the collision due to GPS<br>Black box registering parameters of the vehicle movement | D1<br>D2<br>D3<br>D4 | 17<br>18<br>19<br>20 |

Future safety systems will be able to assess a situation long before a collision and through interfering with the following systems; regulation of driving dynamics, braking and other ones will be trying to avoid a collision. If it is not possible, to minimize the results, the system will define an angle of crash and its estimated force and will adjust adaptation elements of safety systems to calculated parameters of crash. To achieve this aim, common communication and exchange of data among all the electronic car systems (such as ABS, ESP, BAS, servo brakes system, a radar to measure a distance to a road obstruction, GPS and other) will be indispensable.

## 3. SYSTEMS OF NAVIGATION AND IDENTIFICATION

Definition of a city position should relate to streets system. Modern navigation systems are equipped with the indispensable data on CD, and more often on DVD. Except of information regarding road intersections and street names CD's and DVD's also include locations of train stations, tourist locations, hotels and petrol stations. Such electronic maps will be immediately introduced to vehicles' computers and will be updated via the internet with the help of such effective system as UMTS. Future update can concern change of driving direction on one-way streets, new city bypasses and highways. GPS is the foundation of the present navigation systems. GALLILEO system will be used to achieve the same objectives in the future. A navigation system calculates the whole distance at the beginning of a journey on the basis of digital road map information and of current vehicle position. Integrated navigation system leads a driver depicting text and graphic information. Even though, a satellite signal suddenly disappears due to for example driving through a long tunnel, an internal computer is able to update a car's position via signals received from the wheels movement and speed sensors. Today, traffic jam updates are delivered via mobile phones. A client logs into a phone net and the system recognizes the area in which a vehicle is placed. Furthermore, the final destination is inserted with a phone keyboard. Afterwards, a person receives all the indispensable information vital for their travel. The new technology called TMC (Traffic Message Channel) expands presently used RDS systems. RDS allows information about road situation to be received swiftly. If used in tandem with a proper navigation system, it facilitates its use. It is wort indicating that navigation systems can also be used in Poland at present. The problems that should be solved are different system of recording and use of navigation maps used by certain producers that are not compatible with each other. This problem will certainly be solved in the future. [3] However, as for navigation systems , the future belongs to active systems that are able to detect a road of travel and diagnose a vehicle's systems from a distance.

## 4. RECOGNITION OF OTHER ROAD OBJECTS

Creation of such system aims at transmission of additional information to a driver (for example different signs), its usage as a element of a steering-in-a-column system and its usage as a remote control element.

An example of additional information is data transmission regarding road objects, their positions,, warning about dangerous situation. Other information that can be transmitted is distance and speed. In b and c situation this information is vital. Within this system, there are passive systems-depicting only information and active-interfiering in a car systems (change of speed, change of a steering wheel position). The technical methods used are: radar and laser systems, picture transmitting cameras, infra-red detectors and infra-red cameras. Signals and information gathered by this systems are transmitted to a computer and there processed.

## 5. DRIVING IN A COLUMN

The systems describing this issue are known as Intelligent Crusie Control – ICC. Their functioning is concerned with the following:

- an object recognition,
- identification of its distance and speed,
- activating (if needed) an automatic mechanism of distance adjusting and the vehicle's speed to the parameters of a preceding car.

In practice, functioning of the aforementioned system is complemented with such additional functions as a possibility to use an acceleration pedal or an automatic gear box. The ICC systems are the most commonly used within the systems of complementing a driver's work. Laser radars are the most useful devices in such systems.

## 6. STEERING OF LONGITUDINAL AND TRANSVERSE DYNAMICS

In case of longitudinal dynamics, these are the best systems of a driver's work complementation. Such systems as ABS, ASR and their integrated versions are installed either as a standard equipment or at least as a optional. As for the steering systems of transverse dynamics (transverse vehicle stability), they are not as common as the aforementioned ones. It also regards integrated steering systems of longitudinal and transverse dynamics.

The idea of solving the problem of steering longitudinal and transverse dynamics relies on the usage of such existing systems as ABS, ARS etc. and their complementation with the sensors of transverse acceleration, a rotation angle of a steering wheel, pressure in tyres, rotation speed of chassis along a vertical axis. Using the signals received from these sensors, a computer system allows to avoid a loss of stability, respecting longitudinal and transverse forces affecting a car.

## 7. AUTOMATIC REMOTE CONTROL

Usage of this system means a holistic or a partial taking control of steering functions by a car. It requires equipping a vehicle in a system of picture recording and recognition and processing it to useful information for a car's steering mechanisms. It is a fragile element of the system that must fulfill the following requirements:

- vibrations of a vehicle and a picture recording element can not influence a picture stability and possibility of environment recognition,
- a picture recorder needs to adjust very quickly to sudden changes of light intensity (i.e. driving into and out of a tunnel),
- the system must recognize environment at a distance of 150 meters,
- a time of picture processing needs to be very short – 120 seconds,
- the system should recognize environment very well and unmistakably identify a driving path.

One of the most serious problems is recognition of pedestrians' movement at a high speed of driving. These difficulties have led to creation of a system in which „ a path informs a vehicle" about its driven distance. In order for this system to work properly, transmitters should be located along a way. A signal from this transmitters will be received by a special system installed in a car. In this case, a driver's interference is not needed. The driving distance will be calculated through the signal analysis or recognition of transmitter positioning (distance and angle). Information „transmitting by a path' and useful for a driver such as: volume of road traffic, traffic jams, bypasses, weather conditions etc. can be expanded (creation of intelligent path).

## 8. CO-OPERATION BETWEEN A HUMAN BEING AND A VEHICLE

Amount of information transmitted to a driver is one of the most important things. Its lack or excess can be dangerous. Increasing amount of information transmitted to a driver should not take place without adjusting its way of presentation to a driver's perceptions. Exceeding amount of information over a driver's perceptions will result in lack of of proper behaviour. The second important element is ergonomics. Its aim is to minimize a driver's tiredness and make use of various systems possible for them. Not only should the system of information transmission involve such senses as vision and touch but also other senses, i.e. hearing. Receiving a voice message (from for example a phone, a radio, an internal computer) or making a voice command (opening or closing windows, an electronic roof, switching on and off a radio or a phone) can exempt a driver from performing some actions. The next issue is alertness of a driver and its monitoring. Receiving information by a driver is hampered by their tiredness. In order to react to such a state, it is vital to diagnose it at first. It can be done through the following ways:

- indirect conclusions: on the basis of a long time of driving without stopping,
- ordering a driver to confirm their alertness through for example pressing a proper button (confirmation results in starting a car),
- assessment on the basis of parameters' values, characterizing a vehicle's movement: sudden speed changes, sudden longitudinal acceleration, a vehicle's rotation along a vertical axis,
- assessment on the basis of a driving manner – change of rotation angle of a steering wheel, sudden pressing of acceleration and brakes pedals,
- physiological phenomena assessment: assessment of pulse, strength of a steering wheel holding, lowering head and eyelids, frequency of winking.

## 9. SUMMARY

Due to usage of telematic, IT and telecommuniaction solutions, building an intelligent vehicle is not far away. At present, such many matters, regarding systems, have been solved as navigation, increasing of a vehicle's efficency, increasing an access to information or using alternative sources of drive. In the near future, the elements of future complex safety system of a vehicle will be co-operating together in the all three stages of an accident: pre-crash (before an accident), in-crash (at the moment of accident) and post-crash (after an accident). In order for the passengers to be the best protected. Telematic solutions will increasingly be playing an important role in building intelligent transport systems. Complementing systems will be developed as well – a manoeuvre will be initiated by a driver and a complementing system will allow it to be made or will correct it. However, there are other aspects of „intelligent vehicles" usage. One of them regards a psychological barrier resulting from limitations of a driver's will, especially if their plans and aims will not be in line with procedures of a steering system. It may deprive a driver of a driving pleasure and make them only execute system orders. Usage of full automation can deprive a driver of a sense of duty in active participation in driving, weaken their natural reflex and make them dependable from the systems independent from them. In effect, introduction of „intelligent cars" requires not only technical solutions but also changes in drivers' psyche. However, it needs to be remembered that all intelligent systems are not able to act against physics laws and predict irresponsible driver's behaviours.

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Reviewer: Ph. D. Grzegorz Dydkowski