

# UNPRECEDENTED VEHICLE AND TRAFFIC SAFETY INTEGRATING V2X COMMUNICATION

**Dr.-Ing. Peter E. Rieth**

**Dipl.-Ing. James Remfrey**

Continental AG, Division Chassis & Safety

Germany

Paper-Number 09-0182

## ABSTRACT

Networking of active and passive safety systems is the fundamental basis for comprehensive vehicle safety. Situation-relevant information relating to driver reactions, vehicle behavior and nearfield traffic environment are fed into a crash probability calculator, which continually assesses the current crash risk and intervenes when necessary with appropriate measures to avoid a crash and reduce potential injuries. Know-how in the fields of active and passive safety, beam and image vehicle surrounding sensors, and innovative driver assistance systems provide effective protection not only for vehicle occupants but also for other, vulnerable road users. This functionality up till now only relates to the ego- vehicle itself. The next logical step is to integrate V2X communication. The integration of this embedded, in-vehicle wireless communication system allows Car-to-Car (C2C) and Car-to-Infrastructure (C2I) functionality for, e.g. time critical hazard warning. This comprehensive focus on creating cars that avoid crashes, prevent injuries and provide immediate assistance information should a crash prove unavoidable is an integral element of cascaded ContiGuard® protection measures.

## INTRODUCTION

Besides the CO<sub>2</sub> discussion, which currently dominates vehicle specifications, the improvement of driving and traffic safety is the second global trend alongside the enhancement of individual mobility in emerging economies and the trend towards comprehensive information networking on the way to the „always on“ information society (Figure 1).

In vehicle safety systems it is still common practice to develop passive systems – which help mitigate crash-related injuries – as autonomous units, in a separate process from the development of active safety systems that help avoid crashes. The first

decisive improvements in vehicle safety came in the mid-1960s with the introduction of the safety passenger cell, the three-point seat belt, and the optimized crumple zone – all focused on passive safety. With increasing numbers of ABS systems as standard equipment in the late 1980s, the foundations for active electronic safety systems (preventing the accident from happening) were laid.



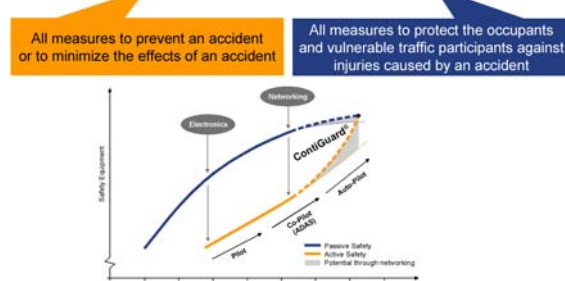
**Figure 1. Automotive Megatrends**

Just how effective the networking of active vehicle safety systems can be, was first demonstrated in a primary phase in 2000, through the Reduced Stopping Distance (RSD) project. In what was called the “30-meter car”, the tires, air springs, variable dampers and electro-hydraulic brakes were linked to form an optimized overall system. As a result, the car’s braking distance from an initial speed of 100 kph was cut from 39 meters to 30 meters, and the total stopping distance was reduced by up to 13 meters, compared in each case with a standard production model car.

Since then, important electronically controlled systems in both the active and passive safety areas have become standard specification in a broad-based vehicle population, systems such as ABS, ESC, belt tensioners, and airbags. These are, however, designed as stand-alone systems (Figure 2). Active and passive

safety developments have until now remained two separate domains.

**Safety = Active Safety integrated with Passive Safety**



**Figure 2. Fundamentals of Safety**

In order to attain optimum protection, however, these systems must be networked by collecting information on vehicle behavior, vehicle environment, and driver reactions, merging the data, evaluating it, and translating it into coordinated protection measures.

Today, for example, Continental's know-how in the fields of active and passive safety, beam and image sensors, innovative driver assistance systems, and tire technology is being channeled into the company-wide ContiGuard® integrated safety concept, in order to achieve a decisive step closer to vision zero, the vision of a traffic without fatalities and severe accidents.

### INTEGRATING ACTIVE AND PASSIVE SAFETY

ContiGuard® brings together the vehicle's active and passive safety systems to form a network. The basic principle is the networking of the driving dynamics data supplied by the Electronic Stability Control ESC with signals describing the driver's behavior and surrounding sensors.

The key integration component is the crash probability calculator, which constantly processes and evaluates incoming data. For any given situation, the calculator computes a hazard potential that reflects the current crash probability.

Should the hazard potential exceed defined limits, the crash probability calculator initiates a function and time staged protection strategy (Figure 3). If, for example, two vehicles are driving nose to tail, various levels of crash probability and pre-crash protection measures can be determined from their relative speeds and the distance between them. Beginning with an acoustic, visual or haptic warning,

these can extend from prophylactic (reversible) seatbelt pre-tensioning, adjustment of seat (anti-submarining), backrests and head restraints, to closing the windows and sunroof.

ContiGuard® represents all driving safety functions by integration of Active Safety, Passive Safety, Vehicle Surrounding Sensors and Safety Telematics.



Example: column driving

**Figure 3. ContiGuard® – Continental Comprehensive Driving Safety System**

Simultaneously, the brake system is preconditioned by boosting the system pressure from pre-fill all the way to limited automatic pre-braking and extended brake assist function.

The full range of measures described above is only available if the vehicle is equipped with a full-power brake system including Electronic Stability Control (ESC) designed to accept external control signals and distance monitoring sensors such as those featured in Adaptive Cruise Control (ACC) systems.

Sophisticated anti-lock brake systems with brake assist functions and adaptive cruise control systems give the driver greater and more comfortable control over the forward dynamics of the vehicle. Modern stability management systems such as ESC can now prevent many skid-related crashes. In addition, electronic control units for airbags, seat belts and rollover protection have significantly improved occupant protection over the last few years.

Advanced surrounding sensors will play a key role in the development of the car of the future designed to prevent crashes and mitigate injuries. New to the market is the development of a pre-crash Closing Velocity (CV) sensor. This highly dynamic sensor, which features a wide short-distance detection range, is ideal for detecting relevant objects very close to the vehicle and enables robust predictions of the severity and direction of an impending crash. This information enables the crash probability calculator to e.g. activate the multi-stage Smart Airbags appropriately or to apply the brakes autonomously. Apart from improving occupant protection, the CV sensor in combination with additional contact sensors

**Function Performance:**

- Autonomous Collision Avoidance up to 30 km/h – stationary target – decel. 0.5g
- Collision Avoidance with driver braking up to 40 km/h on stationary target – decel. up to max.
- Function active up to 50km/h for Collision Mitigation on moving targets

Additionally radar based beam sensors are being further developed to cover a wider object detection range. The ARS300 sensor has the potential to cover both the mid-range and far-range environment, so that active safety systems (preconditioning of the brake system, extended Brake Assist, ...) and passive safety systems (reversible occupant positioning and retention, vehicle interior preconditioning, Smart Airbags, ...) can be realized.

TELEMATIC COMMUNICATION

With comprehensive vehicle safety and traffic management becoming more and more critical aspects of global mobility, the essential cornerstone Telematics will play an important role in efforts to integrate embedded, in-vehicle wireless communication systems into ContiGuard®, which focuses on creating cars that avoid crashes, prevent

The diagram illustrates a vehicle safety system architecture, divided into four main functional areas:

- Active Safety:** This section includes components for vehicle control and driver assistance:
  - ESC (Electronic Stability Control)
  - Wheel Brakes
  - Sensors
  - CSC (Crash & Safety Controller)
  - EPS (Electric Power Steering)
  - ARK (Active Rider Aid Kinematics)
  - EAS (Electronic Air Suspension)
- HMI (Human Machine Interface):** This section includes:
  - AFPP\* (Advanced Frontal Protection Package)
- Safety Telematics:** This section includes communication and data management components:
  - TCU (Telematics Control Unit)
  - e-Horizon
  - V2X (Vehicle-to-Everything) Communication
- Passive Safety:** This section includes components for occupant protection:
  - ACU (Airbag Control Unit)
  - CISS (Crash Impact Sensor System)
  - pSat, gSat (Pressure and Acceleration Sensors)
  - OCS (Occupant Classification System)
  - SRL (Short Range LRR)
  - MRR (Mid Range Radar)
  - LRR (Long Range Radar)
  - Camera

A central orange oval highlights the integration of the Active Safety, HMI, and Safety Telematics components, with a large orange arrow pointing from this central area towards the Passive Safety components, indicating a flow of information or control.

Figure 5 shows the five cornerstones and elements of the modular comprehensive ContiGuard® safety toolbox.

Today, Continental's Safety Telematics systems help to make cars safer and provide a "wireless life-line" to emergency assistance the critical seconds after a crash occurs. In case of an accident, the eCall Telematics Control Unit (TCU) in the car will transmit an emergency call that is automatically directed to the nearest emergency service. eCall can be triggered in two ways. Manually operated, the voice call enables the vehicle occupants to communicate with the trained eCall operator. At the same time, a minimum set of data will be sent to the eCall operator receiving the voice call.

Diagram illustrating the eCall process flow:

- 1** Airbag Control Unit
- 2** Telematic Control Unit
- 3** eCall Information
  - Launch eCall Control (1)
  - Launch eCall (90-1-99)
  - Date of occurrence (00-12)
  - Location
  - Participant 1 (16-15 187)
  - Severity (000-1)
  - Service Provider ID
  - Nbr (9-1-99999-11)
- 4** Communication (Speech and Data)
  - Between vehicle and PSAP
  - via Service Provider or directly routed (e112)
- 5** Emergency services (Police, Fire, Ambulance)

When activated, the in vehicle eCall device will establish an emergency call carrying both voice and data directly to the nearest emergency services

(normally the nearest 112 Public Safety Answering Point, PSAP).

The life-saving feature of eCall is the accurate information it provides on the location of the accident site: the emergency services are notified immediately, and they know exactly where to go. This results in a drastic reduction in the rescue time.

Estimations for eCall carried within the E-MERGE project and the SEiSS study indicate that in the European Union up to 2.500 lives would be saved per year, with up to 15 % reduction in the severity of injuries.

### Integrating V2X Communication

Under development is Dedicated Short Range Communication (DSRC) for vehicles, which allows receiving of traffic and warning information directly from other cars, even those not visible to today's surrounding sensors. Examples for DSRC applications are shown in the following. (Fig. 7 to 10)

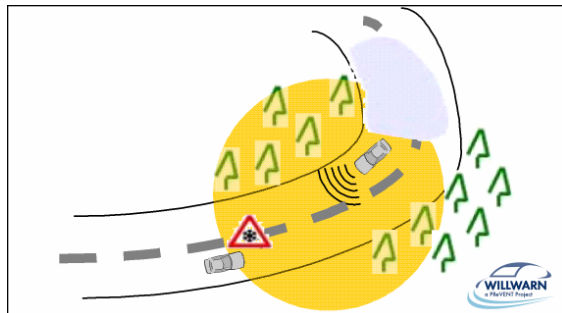


Figure 7. Hazard Warning

**Hazard Warning** - The driver is warned if his vehicle approaches a potentially hazardous situation on the road ahead. Hazards can be construction zones, breakdown situations, accidents, end of traffic jams, imminent forward collision, black ice, etc.

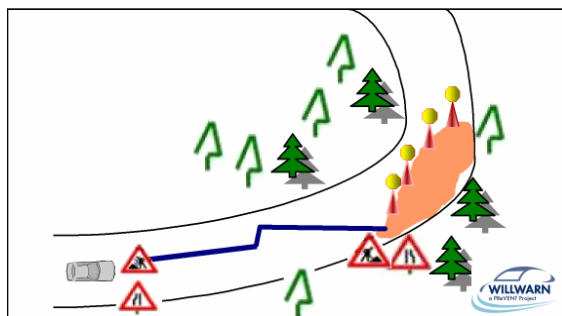


Figure 8. In Vehicle Signing

**In Vehicle Signing** - Display or announcement of localized traffic sign information such as speed limits, temporary right of way changes, traffic routing, etc. It is of particular relevance for, but not limited to, dynamic information.

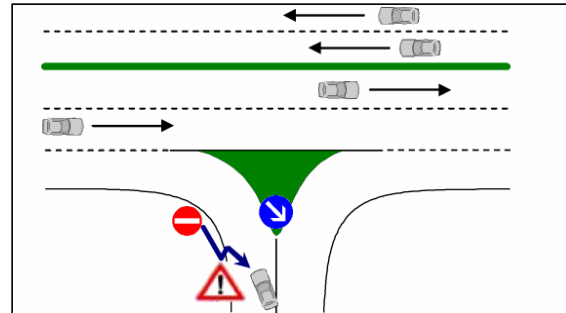


Figure 9. Traffic Rule Violation Warning

**Traffic Rule Violation Warning** - The driver is warned if he is about to violate a traffic rule. This includes traffic signal violations, stop sign violations, right-of-way violation and cross-traffic collision avoidance, etc. It is of particular relevance for, but not limited to, dynamic traffic sign information.

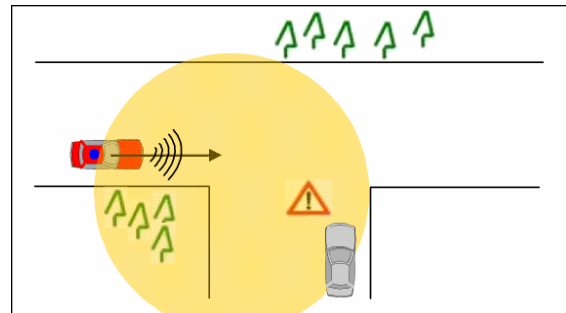


Figure 10. Emergency Vehicle Warning

**Emergency Vehicle Warning** - The driver is warned of approaching emergency vehicles which claim the right of way.

Shadowing by other vehicles, as with beam or image sensors, will be less of a problem and therefore further increase the range achieved in typical driving situations. In addition, information from the infrastructure can be provided, such as traffic light status, position of road works, local weather information, etc. DSRC will reduce the driving risk by providing local hazard warnings and bring active safety to a new dimension.

Combining DSRC and surrounding sensors will lead to cascaded information and actions resulting in a system capable of providing a safe driving state,

helping to prevent crashes and in case needed, reduce the severity of a crash. Therefore, the information from DSRC is taken into account first, validated via surrounding sensors and accordingly supported by actions such as provided by ESC systems.

### **Connectivity**

On the comfort side this next generation of telematics systems will soon offer the motorist even greater freedom at the wheel. Any portable device connected to the vehicle by Bluetooth or USB can be operated either by voice command or from the controls in the steering wheel or instrument panel. In addition, new telematics systems use wireless connectivity to load address books from the cell phone into the car; they can read out incoming short messages and support personalized ring tones and stored speed dialing numbers. An optional, integral telephone module allows both internet access and service and assistance functions, including automatic emergency calls.

### **CONCLUSION**

Today's vehicles have already reached a high safety standard thanks to current, state of the art technologies such as Airbags and the Electronic Stability Control System ESC. Networked active and passive safety is in the market and is already being equipped to premium class vehicles and in the future be enhanced by telematics – in this case by eCall. But telematics also offers possibilities for safety related vehicle communication in the future, namely V2X. The information cascade for safety systems improves the range of, for example, ContiGuard®.

Cascading starts with DSRC, is validated by surrounding beam and/or image sensors and the performed actions are supported by electronically controlled safety systems e.g. ESC and/or intelligent restraint systems.

Connected Safety Telematics offers comprehensive traffic safety and can be combined with service providers with the aim to provide intelligent mobility.

Furthermore, Continental will participate within a four-year, practical field test for Safe Intelligent Mobility (SIM-TD). The purpose of this project, which will be staged in the Rhine-Main region around Frankfurt in Germany, is to equip and network vehicles and the transport infrastructure with communication units. By means of car communication units (CCU) and road side units (RSU), relevant information can improve traffic

efficiency and road safety by utilizing innovative telematics technology: hazard warnings can be exchanged directly between the participating vehicles, for example. These automatically detect critical road conditions by means of the on-board sensors. The same applies in the case of accidents. The real-time information is supplied to nearby vehicles, warning them, for example, about accidents, icy roads or traffic jams which normally cannot be detected in time by approaching vehicles.

### **REFERENCES**

- [1] Communication from the Commission: The 2nd eSafety Communication – Bringing eCall to Citizens, Brussels, COM(2005) 431 final, 14<sup>th</sup> September 2005
- [2] German Association of the Automotive Industry (VDA), Annual Report 2007, Vehicle-to-vehicle and vehicle-to-infrastructure communication
- [3] Europa Press Release, i2010 Intelligent Car Initiative, IP/07/1346, 18<sup>th</sup> September 2007
- [4] Dr. Karl-Thomas Neumann, VDA Technical Congress, Automobile Communication Platform Networking of Vehicles and Infrastructure, Ludwigsburg, 2<sup>nd</sup> April 2008
- [5] Dr.-Ing. Peter E. Rieth, Dipl.-Ing. James Remfrey, SAE Convergence 2008, Paper Number 08CNVG-0034, "Telematics – the Essential Cornerstone of Global Vehicle and Traffic Safety", Detroit, USA, 20<sup>th</sup> October 2008