



The Safe Communication Platform

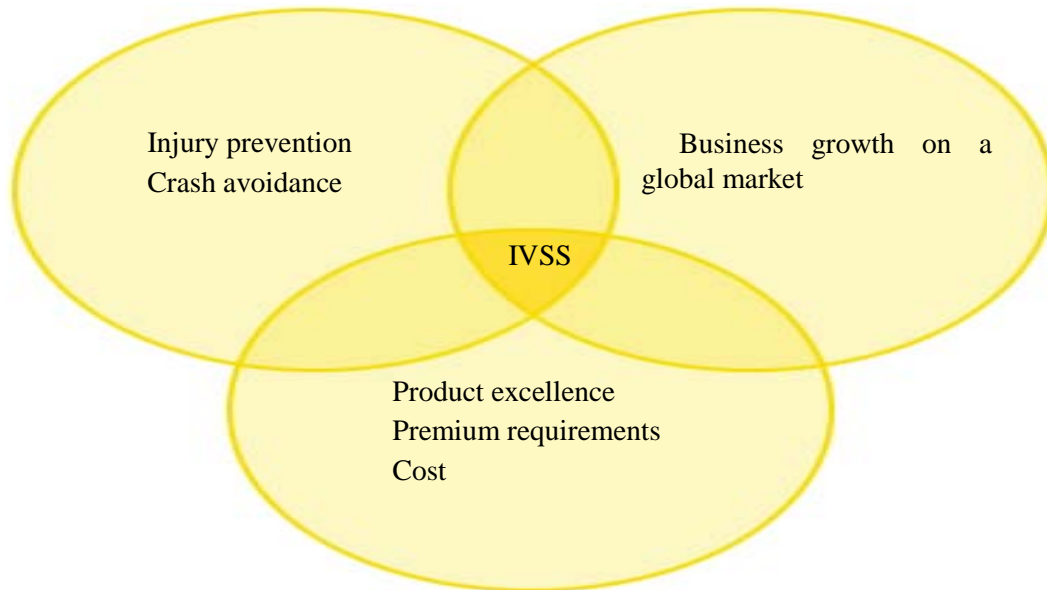
IVSS Project Report

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The IVSS Programme

The IVSS programme was set up to stimulate research and development for the road safety of the future. The end result will probably be new, smart technologies and new IT systems that will help reduce the number of traffic-related fatalities and serious injuries.

IVSS projects shall meet the following three criteria: road safety, economic growth and commercially marketable technical systems.



Three interacting components - for better safety, growth and competitiveness:

The human being

Preventive solutions based on the vehicle's most important component.

The road

Intelligent systems designed to increase security for all road users.

The vehicle

Active safety through pro-active technology.



VOLVO

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Table of contents

- 1. Summary 5**
- 2. Sammanfattning..... 5**
- 3. Background 6**
- 4. Achieved results 7**
- 5. Contribution to IVSS objectives..... 9**
- 6. Recommendations..... 10**

1. Summary

The main focus in this project has been an investigation how to implement a safety related wireless communications system in vehicles and to achieve a sufficient good link quality. A guideline has been developed consisting of methods and tools to design transmission links from the front-end of transmitters to the front-end of the receivers.

The methods to derive parameters make use of analytical calculations, computer simulations, measurements, estimations or parameters are taken from technical specifications. To facilitate the use of the guideline parameters are entered in a comprehensive link budget evaluation sheet (LBES). The LBES is in A3 format and has also been implemented as an executable Excel sheet. In this way the link margin can conveniently be calculated and the result will show if a system will work or not.

2. Sammanfattning

Projektets huvudmål har varit att undersöka hur säkerhetskritisk trådlös kommunikation kan implementeras i fordon med tillräckligt god länkkvalitet. En lathund, bestående av metoder och verktyg, har utvecklats som stödjer designen av kommunikationslänkar mellan sändare och mottagare.

Vid parameterframtagningen används antingen analytiska beräkningar, dator simuleringar, mätningar eller uppskattningar eller så tas parametrarna från tekniska datablad. För att stödja framtagningen av länkprestanda har ett grafiskt hjälpmedel, kallat *Länkbudgetutvärdering*, utvecklats. Hjälpmedlet är i pappersformat och finns också i EXCEL. Länkparametrarna kan därmed enkelt beräknas och resultatet kan användas för att visa om ett tänkt kommunikationssystem kommer att fungera eller inte.

3. Background

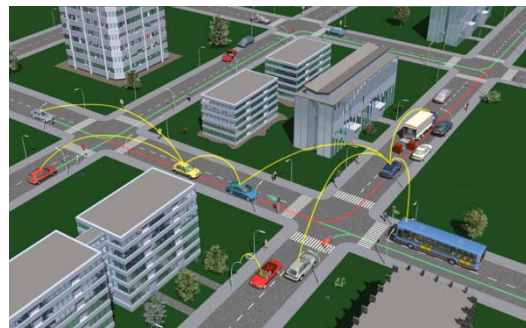
In 2004, the US police reported 6 million light vehicle crashes that resulted in an estimated loss of 2.8 million functional years at a cost of 120 billion \$. The statistics can be found in “Pre-Crash Scenario Typology for Crash Avoidance Research” (DOT HS 810 767) from National Highway Traffic Safety Administration (NHTSA), also called “37 crashes report”.

The whole car industry is striving to develop systems that will take an active part in mitigating the consequences of car crashes and also aiding the driver during driving. Sensors that sense the surrounding environment and give information to the driver will gradually take active part in preventing accidents. An example is adaptive cruise control which uses radar to automatically keep a distance to the vehicle in front. The main task of any active safety system is to reduce the number and severity of road accidents.

The research and development work in the active safety arena is mainly following two tracks where the first products based on sensor systems has reached a maturity level where vehicle installations has started to emerge on the market. Most important application will probably be Collision Mitigation by Braking but other comfort oriented applications like Lane Departure warning, Forward Collision Alert and Traffic Sign Memory are already implemented in some high end cars. Those functions are heavily relying on sensor technologies like camera, RADAR and LIDAR, adding pre-crash braking capabilities and comfort functions to vehicles

During the last years telematics and position services have been implemented. Especially, the mobile telephone networks (e.g. GSM/GPRS) have been used to send messages, fleet management, and alarm signaling. However, the demand on accessibility, response time, transmission capacity on these systems increases.

Communication between cars (C2C) and between cars and infrastructure (C2I) is gaining increasing interest as a means to avoid or at least mitigate accidents. The link quality of this communication system has to be extremely good when a collision between two vehicles is imminent. Then, to avoid a fatal situation, the first vehicle has to transmit a message alerting the dangerous situation and the other vehicle has to correctly interpret the message in an extremely short time interval. Those systems are totally dependent of accurate positioning and robust communication. The communication system must be able to establish a communication link to all cars within a defined radius, to prioritize a large number of messages and to handle, sometimes severe, interferences like multi-path and fading.



In the future a rapid growth in area of C2C and C2I communication can be foreseen even more increasing the difficulty to design an antenna system with respect to parameters like packaging, interference and communication integrity.

This C2C and C2I growth may lead to “antenna farms” with up to 20 antennas on vehicles which are or will be used for communication or as sensors. Antennas for communication are used for exchange of information either internal in the vehicle or with external systems, see Fig. 3.1.

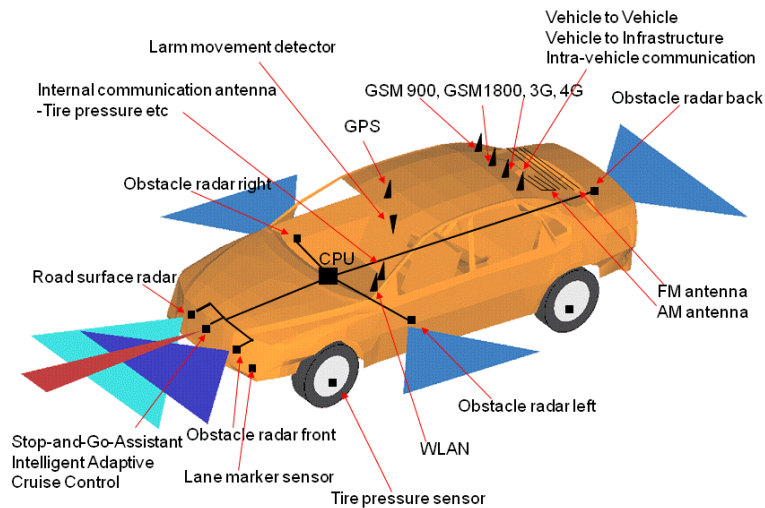


Figure 3.1. The connected vehicle

The communication links must as a minimum meet stringent requirements regarding transmission conflicts, system interaction, data integrity and latency time. The system is comprised of various components where the transmission link also can be seen as a component.

4. Achieved results

The main focus for the *Safe Communication Platform (SCP)* project has been how to implement C2C and C2I wireless communications system in vehicles to achieve a sufficiently good link quality. The findings has been summarized in an implementation guideline to facilitate the usage of the results in future design work

In order to obtain a safe communication in a cost effective way, antennas, cables and electronics have to be placed at optimal positions relative to each other. This may be done already in the construction phase so that different solutions can be evaluated before testing.

When new systems are added, the requirement to shorten the time from concept study to market introduction is getting more and more important for every new vehicle model. This means that the time allocated for testing and modifications also is shorter. There is therefore a need for methods that could be used for selecting communications system solutions and antenna positions in an intelligent way and as early as possible in new development projects. The reported project has investigated the most important parameters of radio communication systems, enabling simplified future transmission link design coupled to more robust communication solutions.

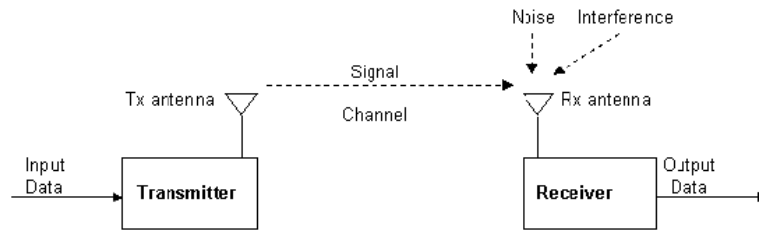


Figure 4.1. Block diagram of a digital radio system consisting of transmitter, receiver and channel.

One example of when the link quality of a communication system has to be extremely good is when a collision between two vehicles is imminent. Then, to avoid a fatal situation, the first vehicle has to transmit a message alerting the dangerous situation and the other vehicle has to correctly interpret the message in an extremely short time interval.

An example of the other extreme is when the link quality could be low is the transmission of the message “Icy road” from an infrastructure system to vehicles some kilometers away. This situation is not time-critical and retransmission or even loss of data can be allowed. Both examples are situations where the guideline can be used to analyze, develop or design new or existing communication systems.

The guideline consists of methods and tools to derive parameters in the transmission link from the front-end of the transmitter to the front-end of the receiver. In general terms the transmission link includes the transmit antenna characteristics, the total radiated power (TRP), how the signal propagates and undergoes degradation due to path loss, fading and in addition is affected by noise and interference. Finally at the receiver side, the antenna characteristics, the available power and receiver sensitivity are considered when calculating the link margin.

The methods to derive parameters make use of analytical calculations, computer simulations, measurements, estimations or parameters taken from technical specifications. Analytical calculations have been used to calculate the path loss in different environments. Computer simulations together with CAD-models of vehicle and antennas have been used to compute e.g. the total radiated power. Measurements in a reverberation chamber have been used to simulate fading environments.

To facilitate the use of the guideline, parameters are entered in a comprehensive link budget evaluation sheet (LBES). The LBES is in A3 format and has also been implemented as an executable Excel sheet. In this way the link margin can conveniently be calculated and the result will show if a system will work or not.

To get an understanding of how to use the guideline four examples including satellite to vehicle, vehicle to vehicle (C2C), vehicle to infrastructure (C2I) and internal communication are given.

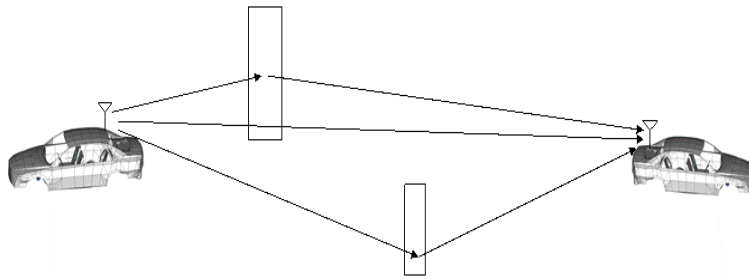


Figure 4.2. Vehicle to vehicle link in a multipath environment.

In the V2V example a WLAN 802.11b system with a distance of 100 m between the transmitter and receiver in a typical urban environment is analyzed. It is shown that it probably will not work, especially if the vehicles are moving the communication link will be broken. Additional information are given in the appendices for providing a deeper in-sight in special subject fields. One example is how fading degrades the link quality, but here are also techniques to mitigate fading effects presented.

The project has ended with much better understanding of the communication requirements thus enabling a faster introduction of C2C and C2I safety systems leading to improved safety for road users.

5. Contribution to IVSS objectives

The IVSS programme has set three main targets that shall be addressed in supported projects:

- improved safety for road users
- business growth opportunities
- increased competition strength

The Swedish vehicle industry has for many years designed and manufactured vehicles meeting very high safety requirements. This is often mentioned as one important factor behind the fact that Swedish vehicle industry has been able not only to survive but also prosper on a market where the competition is well known to be extremely fierce. This ambition synchronizes well with the “Vision Zero” defined by Swedish Transport Administration. Vision Zero states that in the future no one shall be killed or seriously injured in road traffic. The CPS project is an important contributor to this objective since the result addresses a key question about communication link integrity and feasibility in active safety systems.

The vehicle industry is now developing the next generation of safety systems where advanced sensors and electronics together will enable features where vehicles will be able to actively mitigate or even avoid accidents. To simultaneously maintain and increase the competitiveness edge and support the Vision Zero, deepened and expanded knowledge in the active safety area is

of vital interest for the whole Swedish vehicle industry where CPS has contributed by moving the knowledge base to a new and very useful level.

Active safety systems will see a dramatic growth in the coming years, leading to expanded business opportunities and growth for those companies that have prepared for the challenge. The rapid growth is based on a combination of technology breakthrough in the sensor area regarding hard- and software and a never ending cost reduction for electronic components. The CPS project result will in the future contribute to this new business area by smoother and quicker development of safety related communication links.

6. Recommendations

More research and development work in the area of communication links is needed before a wide introduction in the market place can take place. One important field is antenna solutions where the driving factors are performance, packaging and cost. Other areas of research interest are communication protocols, communication integrity, graceful performance degradation and other functional safety aspects.

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