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Car Navigation Systems

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1. Introduction

A navigation system in the automotive branch is a complete HW and SW system. It is design to calculate and guide the drivers to their determined destination.

There are many categories of Navigation systems as for example the integrated on the infotainment systems in cars and the portable systems. The focus of this paper will be the integrated systems. These systems are more complex in HW as well as in SW.

As introduction for the most complex systems I would like to describe the most common components of all car navigation systems.

1.1.Map data

The map data is a basic component for a navigation system. In the map database mainly are stored the motorways with their different attributes (e.g. form of way, functional road class, speed category, etc.) and also could be included some polygonal information as for example the land use or street blocks (mainly use for HMI proposes) and finally some points of interest (POI) representing special locations that the user could ask for; normally the user could edit it and add new POIs to the system.

1.2.GPS

The global positioning system (GPS) is use in the navigations systems to determine the current car position. The USA defense ministry developed this system in 1973 and it based on satellite signals from satellites around the word, a control segment based on a master control station located in Colorado Springs and 4 other stations around

the word these stations are charged of the complete control of the system; the final component of the GPS is the GPS receptor. All these three components trough mathematical calculations make it possible to determine the position of an object on the earth.

Figure 1.1: Satellite orbits for the GPS systems

The main error sources on the GPS is that according to the military propose for which was designed the GPS on April 2000 the US army set a distortion signal to decrease the quality of the measurements on civil uses. This distortion signal is now retired for the most regions of the word but the errors on the measurements could be caused for external factors as: the effect of multi reflection that could be present on areas close to electrical components or radio transmitters.

These error sources are really present in a car navigation system for that reason the location of the GPS antenna should be selected very carefully. Also factors on the Ionosphere and Troposphere could source on error on the GPS.

For the implementation of car navigation systems the presence of trees and building could be an obstacle to receive the signal of four satellites at the same time (needed to calculate the position) and also the totally lost of satellite signals should be consider as for

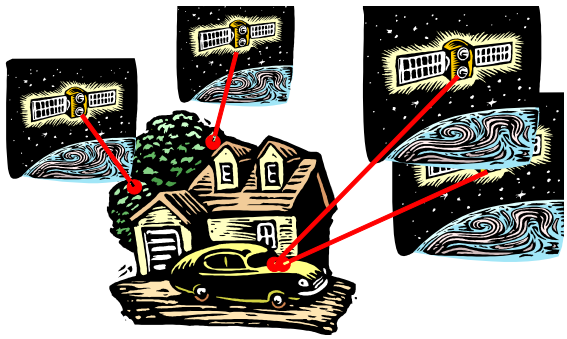

Figure 1.2: GPS reception on car navigation systems

example in a basement parking place or a tunnel, for that reason the more complex navigation systems are equipped with some extra HW to calculate the car position. This equipment will be discussed in the next chapter.

1.3. TMC

The traffic message channel (TMC) is use in many European countries to send valorous information regarding the traffic conditions on the different ways. The traffic announcements (TA) are transmitted using the radio data system (RDS). The TA are transmitted in a digital way and are not hearable for the driver this make possible to transmit the TA with out having to interrupt the radio program.

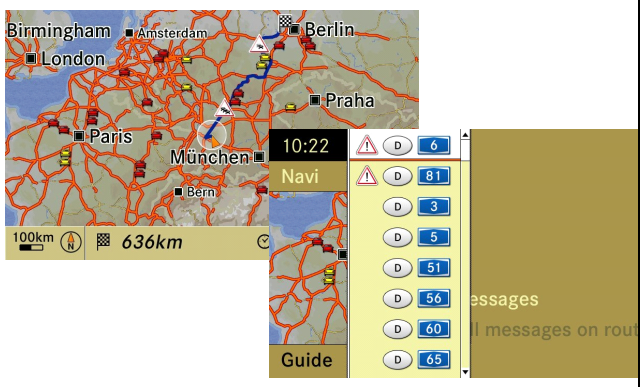

Figure 1.3: TMC screen shots on a car navigation system

The TMC is nowadays is completely available in Germany, Nederland, France, Austria, Switzerland and Great Britain.

The TMC are transmitted using the ALERT-C protocol (Advice and problem location for European Road Traffic version C).

1.4. General MMI

1.1.1. Input data components

The user has many possibilities to enter data or to control the system. The most common are: the DDS use by Audi and many after mark systems, the CCE use by Daimler and BMW, touch screen use for many after mark systems and PDA navigation and speech dialogue system (SDS) which allow the user to introduce the destination or navigate on the menu system using voice commands.

1.1.2. Route guidance

The system will guide the driver using visual or acoustic route guidance.

The visual route guidance could be in form of an arrow navigation in which the driver will see the route guidance as arrows and other symbols it is the cheaper way. The more expensive way is the map navigation in which the user will have the possibility to visualize the complete map and commonly in colors in addition to the arrow information. The map navigation could be in 2D or 3D depending of the processing and graphical capabilities of the system.

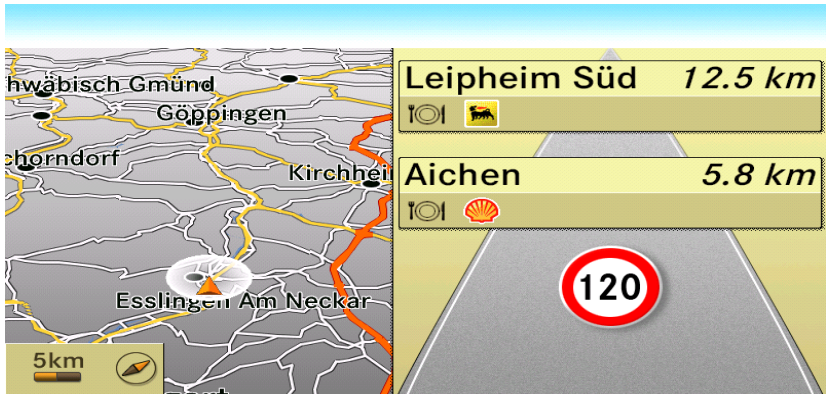

Figure 1.4: Visual route guidance on a car navigation system

Beside or in addition to the visual route guidance there is acoustic route guidance. Typically there are three types of notifications to the driver. The two first notification are to prevent the driver for an action that should be execute on the

way ahead; these two notifications are in different distance interval depending the systems and the location of the car (inside cities or highways) the third notification is the action notification and this indicate the driver to conduct an action immediately. Beside the notifications the navigation system normally include a repeat taste to allow the user hear again the latest voice advice.

2. HW Components of an automotive navigation system

Beside the GPS the more complex navigation systems include more HW to allow the system to determine the position of the car. In this chapter I would like to describe the most common HW components of a car navigation system. Of course this complexity in the systems means also an increase in the cost of the systems compared with after market or portable systems. It is important also mention here that many of these HW components are not use exclusively by the navigation systems. Many of these components are used for other systems inside the Vehicle and are independent electronic control units (ECU) communicating each other using mainly a controlled area network (CAN) bus.

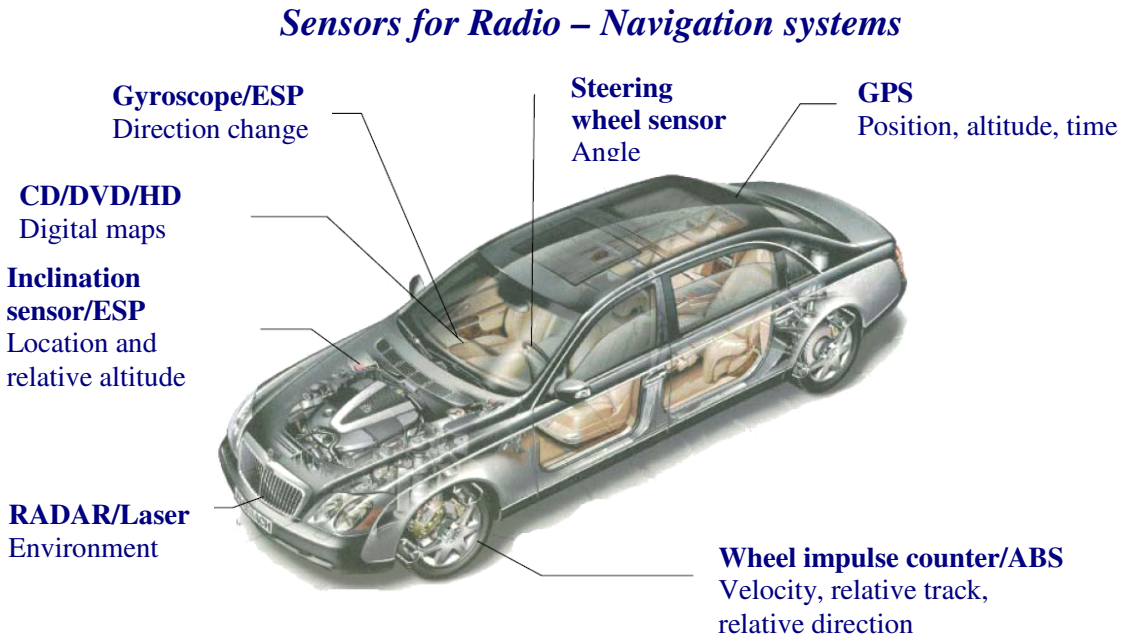

Figure 2.1: HW components on a car navigation system

2.1.Gyroscope:

The changes on direction are detected by the gyrometer. This component transform the changes on his position in electrical impulses with these impulses can the computer know if the car accelerate, stop or change of direction.

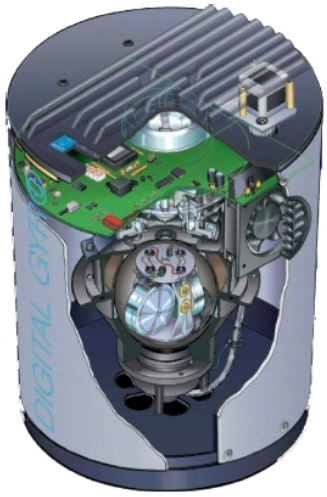

Figure 2.2: Gyroscope

The advance of this component is the small size and the minimum influence of the distortion fields present on the car.

This component is very important when the signal of the GPS is lost, for example in a tunnel. Using the information of the gyrometer the system can compare the route of the car and the map information to continue with the correct route guidance.

In case the car reach a position that is not include in the map data, the gyroscope could be use to determine the car direction and indicate the driver the best way to return to the way included in the map information.

2.2. Wheel impulse counter / ABS:

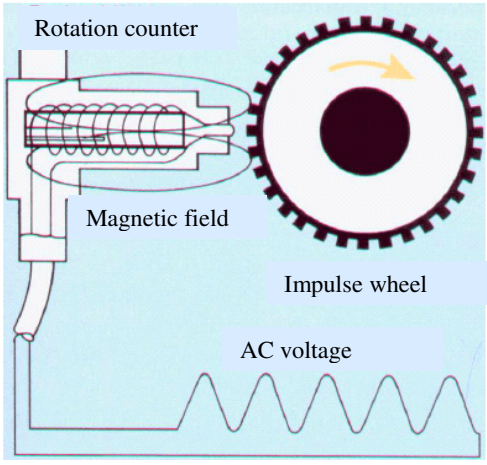

Figure 2.3: Wheel impulse counter

For the positioning of the navigation system of the first generation was very usual the use of two inductive wheel rotation counters to determine the way and a change on the direction of the vehicle as well as earth magnetic field sensor to determine the absolute driving direction.

The GPS signals where use more commonly to correct strong sensor distortions or after driving in a not digitized map zone to return to the saved way net.

The new systems are using an easy way signal of an electronic tachometer as it is used in the speed automatic volume regulation of the Auto radios. Die tachometer send drive speed proportional impulses that can be interpreted in the navigation systems.

2.3.Steering wheel sensor:

Some systems include this component that could be used to determine the car direction. It is a very simple component that registers the angle in which the steering wheel is rotated and this information can be use by the navigation system to calculate the driving direction.

2.4.Inclination sensor/ESP:

This component could be use in combination with the wheel impulse counter to determine the altitude in which the car is.
This component transmits to the system the inclination angle of the vehicle and the system could calculate the relative altitude of the vehicle.

2.5.RADAR/Laser:

Nowadays many vehicles include radar and laser sensors to determine the condition on the way. These systems provide information to the driver regarding the way as for example a vehicle in front stopping very fast. All these information could be show as an alert message in the navigation system or as an acoustic alert message to the driver.

Some sensors provide also information regarding the whether conditions and this information is processed by the navigation system and provided to the user as alert messages.

3. SW components of an automotive navigation system

The SW structure of the navigation systems is different from company to company and the complexity of the systems.

In order to understand in a better way the navigation systems I would like to provide an example of a SW structure of a complex navigation system and explain some of the more important SW blocks.

Taking in consideration that the navigation system in the more complex systems is integrated in a complete automotive solution the SW structure could be as following (the example is taken from the German market).

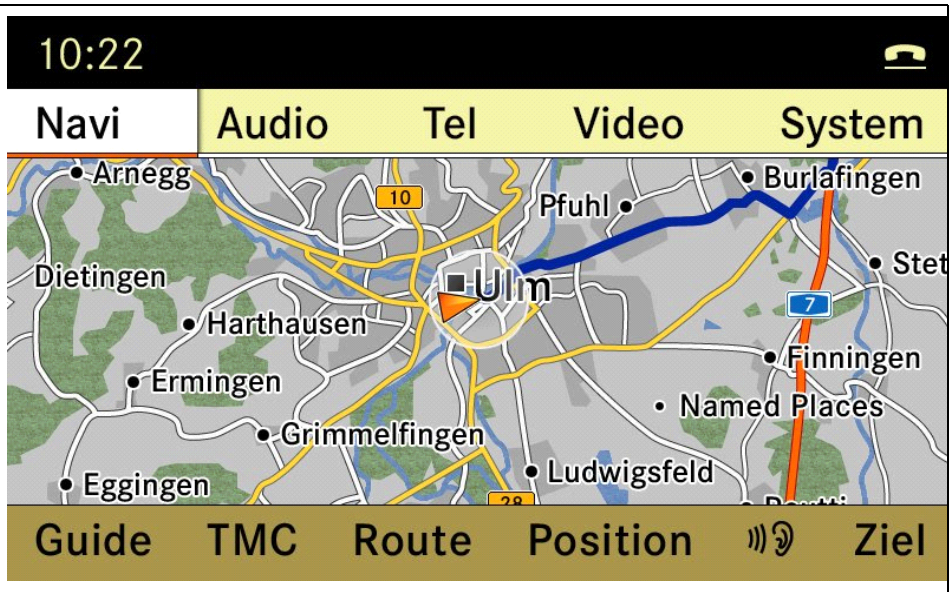

Figure 3.1: Complete HMI of a car infotainment system

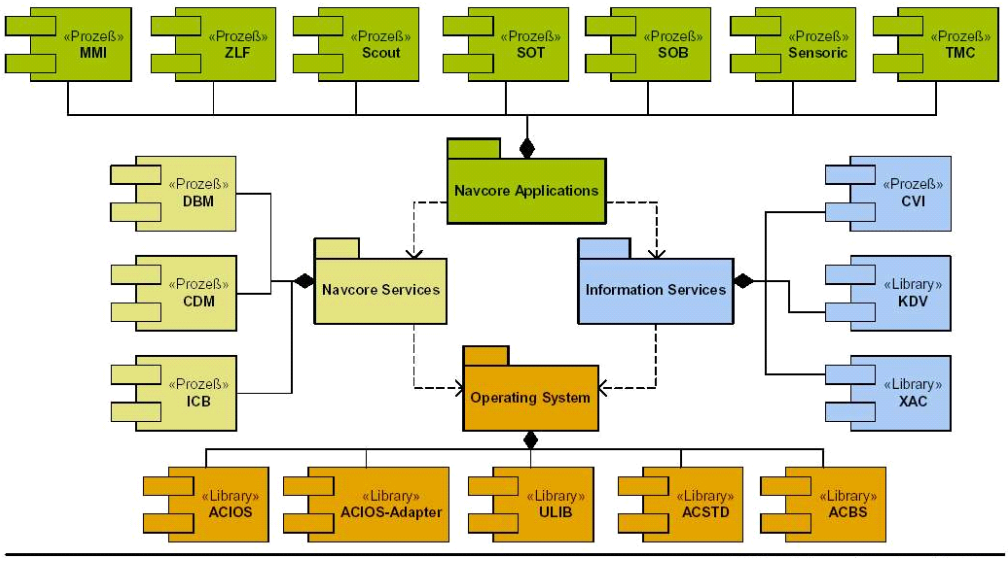

Figure 3.2: Block diagram of a car infotainment system

3.1.MMI:

This block is always present in the navigation systems. This module is responsible of the communication between all the other modules and additional could be responsible to complete information of the position description for example for a determined coordinated that is located in a street provide the correspond name.

3.2.ZLF:

The abbreviation ZLF come from the German word “Zielführung” for route guidance this module is responsible to provide all relevant information for the graphic route guidance and the acoustic advices and coordinate with the “Scout” module the route calculation. This module is also present in all navigation systems.

3.3.Scout:

This module is present in all automotive navigation systems and it is responsible to calculate, evaluate and find an optimal route from a start point to a destination point. Optimal route means a route that full fit and determined conditions as for example shorter way or less consuming time way.

3.4.SOT:

SOT is the abbreviation of the German “Standort-Tracer” that mean position tracer. This module is responsible to trace the vehicle position in case of an off road navigation. This module stores a list of already past points and uses it to advice the driver to the digitized way net.

3.5.SOB:

SOB module from German “Standortbestimmung” for position calculation is responsible to calculate the current vehicle position with help of the “Sensoric” module.

3.6.Sensoric:

This module is responsible to collect all the information from the sensors around the car. In case of simple systems the module could be replace for a GPS module. In the most complex system this module will collect information from the gyrometer, radar, laser sensor, etc.

3.7.TMC:

The TMC module is responsible to collect and manager all traffic announcements. Some simple systems are not provided with this module. Nowadays most of the navigation systems in Europe are equipped with a TMC module that makes possible to receive the TAs and provide this information to the route calculation on the "Scout" module.

3.8.DBM:

This module is responsible for the process of the geo-database and provides the correct data to the other modules

As I mentioned before the example is a part of a complete automotive infotainment system. The other modules showed in the block diagram are more related to the complete system but also could have some interaction with the navigation system. The operating system is the base for the other systems and provides the basic functions to the other components. Inside the Information systems could we have the management of the other databases that are include in the system as for example the address book, media database, etc.