TEHNOLOGIJE MODERNOG AUTOMOBILA

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VELEUČILIŠTE U ŠIBENIKU

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MODERN CAR TECHNOLOGIES

Završni rad

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TEHNOLOGIJE MODERNOG AUTOMOBILA

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Sažetak rada:

U ovom radu će biti detaljno opisane neke od najznačajnijih tehnologija koje čine moderne automobile. Prva tri poglavlja ovog rada će objasniti kako su se stvari promjenile u automobilima u vidu povećanja snage i učinkovitosti iskorištavanja goriva kroz razvoj motora i lakih materijala. Daljnja poglavlja će prezentirati elemente sigurnosti koji su podjeljeni na aktivne i pasivne elemente sigurnosti. Biti će moguće vidjeti da su najveći napretci napravljeni u aktivnim elemtima sigurnosti kao što su "vision" sustavi i sustavi kočenja i stabilnosti. U zadnjem dijelu biti će riječ o informacijskim sustavima, komforu i praktičnoj primjeni tehnologija u autoškolama. Unatoč činjenici da su svi spomenuti izumi važne tehnologije modernog automobila, biti će dana malo veća važnost onima zvanima elementi siguirnosti, naročito aktivnim elemntima sigurnosti.

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MODERN CAR TECHNOLOGIES

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Abstract:

In this thesis the most significant technologies that define a modern car will be described in detail. The first three chapters of this work will explain how things have changed in cars when it comes about power and fuel efficiency through the development of engines and lightweight materials. Further chapters will address safety features which are divided in active and passive features. It will be able to see that the biggest improvements are being made about active safety features such as vision technologies and stability and braking technologies. In the last part there will be a word about infotainment systems, comfort and practical usage of technologies in driving schools. Despite the fact that all mentioned inventions are important modern car technologies, there will be given slightly bigger importance to those features called safety features, especially the active safety features.

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Contents

1. FOREWORD

The development of road vehicles has started over a hundred years ago. The year 1886 is regarded as the birth of the modern car. In that year, German inventor Karl Benz built the Benz Patent-Motorwagen. Cars did not become widely available until the early 20th century. One of the first cars that were accessible to the masses was the 1908 Model T, an American car manufactured by the Ford Motor Company. Cars were rapidly adopted in the United States of America, where they replaced animal-drawn carriages and carts, but it took much longer for them to be accepted in Western Europe and other parts of the world. Because of humans` wish to drive faster vehicles, car industry became one of the main businesses in the whole world. Due to great development of industry some vehicles these days are moving at terrifying speeds. That is one of the key elements responsible for such a big number of accidents. To reduce the number of accidents and mitigate their consequences the development of different technologies starts conforming time in which they appear. The beginnings of these technologies are related to mechanical innovation but the development of electronics causes the appearance of even more advanced circuits that lead into the field of artificial intelligence. Precisely the phenomenon of artificial intelligence leads to needs of the development of communication between vehicles and communication between vehicles and the traffic infrastructure. Although we are emphasising projects and technologies that are almost "futuristic" it must not be forgotten that only a decade ago devices for parking assistance or HUD systems were also almost unthinkable in everyday usage and these days are almost standard equipment of the vehicle. However, according to fact that a human also has a great impact in traffic, there will always be accidents. There is a task, and it is the subject of this work, to prevent accidents that are not strictly caused by the speed. Also it is explained in which ways it is possible to reduce the consequences of accidents. Features which are mentioned to prevent accident are called “Active safety features” and features which are constructed for reducing the damage and injuries after it already happened are called “Passive safety features”. Despite safety there is always the desire to make a car which can be as fast and comfortable as much as possible.

The first three chapters of this work are explaining how things have changed in cars when it comes about power and fuel efficiency. Further chapters address safety features and in the last part about infotainment systems, comfort and practical usage in driving schools. The purpose of this thesis is to explain the most significant features and invents that define a modern car.

2. MODERN ENGINES

Compared to other technologies used every day, it seems like car engines have not really changed much. The engine in an old Ford Model T has plenty in common with the engine in a 2011 Ford Fusion. Car engines use the same basic principle: The combustion of air and fuel to create rotational force and move a car.

Before a word about how modern car engines are different from older ones, it is important to understand the basics of how a car engine works. Basically, gasoline and air are ignited in a chamber called a cylinder. In the cylinder there is a piston that gets moved up and down by the gasoline/air explosion. The piston is attached to the crankshaft. As the piston moves up and down, it makes the crankshaft rotate. The crankshaft goes out to the transmission, which transmits that power to the car's wheels. With modern engines the basics still apply, but there is a lot more to think about. Basic gasoline car engine is not all that efficient. Of all the chemical energy in gasoline, only about 15 percent gets converted into the mechanical energy that actually moves the car.[1]

2.1. Direct fuel injection

2.1.1. Direct fuel injection definition and explication

Direct fuel injection is a fuel-delivery technology that allows gasoline engines to burn fuel more efficiently, resulting in more power, cleaner emissions, and increased fuel economy.[2]

Gasoline engines work by sucking a mixture of gasoline and air into a cylinder, compressing it with a piston, and igniting it with a spark; the resulting explosion drives the piston downwards, producing power. Traditional (indirect) fuel injection systems pre-mix the gasoline and air in a chamber just outside the cylinder called the intake manifold. In a direct injection system, the air and gasoline are not pre-mixed; air comes in via the intake manifold, while the gasoline is injected directly into the cylinder, which is shown in the Figure 1.[3]

[1] »http://auto.howstuffworks.com/5-ways-modern-car-engines-differ-from-older-car-engines.htm«, 20.05.2016.
[2] http://cars.about.com/od/thingsyouneedtoknow/a/directinjection.htm
[3] »http://cars.about.com/od/thingsyouneedtoknow/a/directinjection.htm«, 20.05.2016.

2.2. Advantages of direct fuel injection

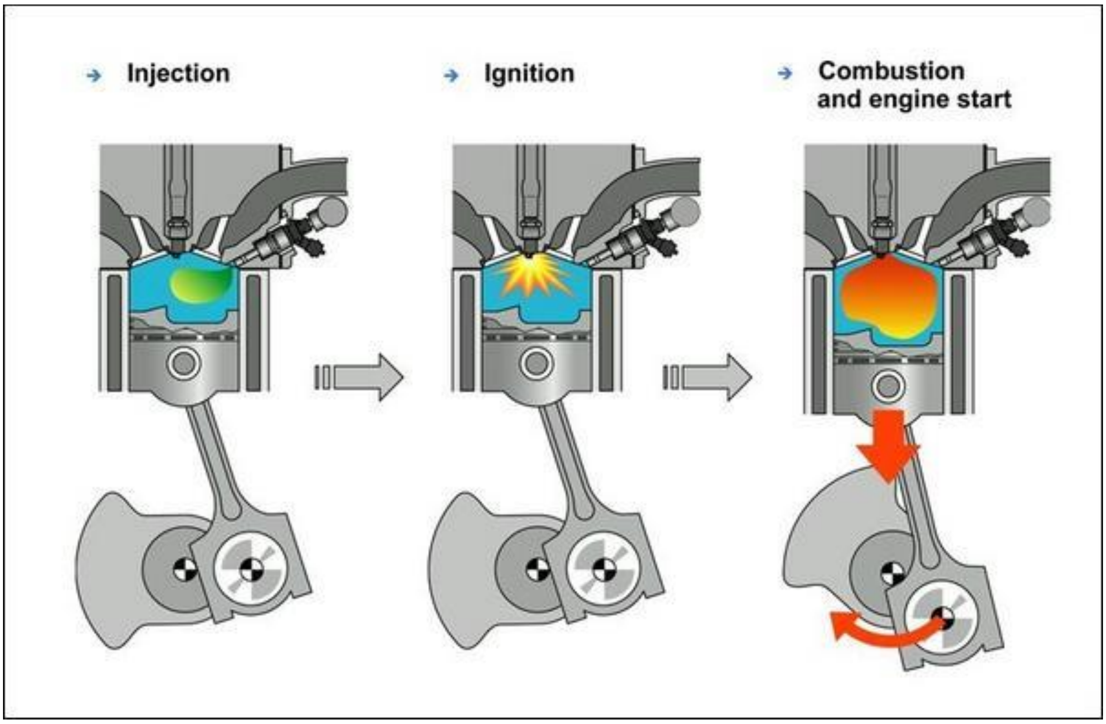
Combined with ultra-precise computer management, direct injection allows more accurate control over fuel metering (the amount of fuel injected) and injection timing (exactly when the fuel is introduced into the cylinder).

The location of the injector also allows for a more optimal spray pattern that breaks the gasoline up into smaller droplets. The result is more complete combustion -- in other words, more of the gasoline is burned, which translates to more power and less pollution from each drop of gasoline.[4]

2.2.1. Disadvantages of direct fuel injection

The primary disadvantages of direct injection engines are complexity and cost. Direct injection systems are more expensive to build because their components must be more rugged -- they handle fuel at significantly higher pressures than indirect injection systems and the injectors themselves must be able to withstand the heat and pressure of combustion inside the cylinder.[5]

Figure 1. Direct injection system



http://performancedrive.com.au/wp-content/uploads/2011/07/direct-injection.jpg, 21.05.2016.

[4] »http://cars.about.com/od/thingsyouneedtoknow/a/directinjection.htm« 21.052016.
[5] »http://cars.about.com/od/thingsyouneedtoknow/a/directinjection.htm« 21.05.2016.

2.3. Turbocharging

2.3.1. Turbochargers (turbos)

"In the most basic definition, a turbocharger is a device that drives more air into an engine."[6] [29] The simplest way to understand them is to consider that an engine needs to mix fuel and air to run. Turbos force more air into the cylinder, which can be mixed with more fuel to create more power. Turbos use the energy of the engine's exhaust gasses to compress air into the engine.

Turbos are formed of two main parts – a turbine and a compressor. These are linked so, when the one spins, the other spins with it. As fuel in the engine is burnt, exhaust gasses are forced out of the engine at high pressure, down a snail-shaped tube to spin the turbine. This turbine spins at incredibly high speeds (up to 250,000rpm) and causes the compressor (effectively a reversed turbine) to spin. This sucks significantly more air into the engine than a normally-aspirated (non-turbo) unit, making more power.

Turbos run at immense speeds which means they operate under huge pressures and temperatures. Typically, an intercooler is paired with the turbocharger to cool the hot air coming out of it and an oil cooling system ensures the turbo itself doesn't run too hot. That is possible to see in the Figure 2. Diesels, having tougher engine blocks and simpler intakes, are ideally suited to being turbocharged so all modern diesels have them.[7]

2.3.2. Benefits of turbochargers

"The turbocharger is the single most significant engine component or add-on device for increasing horse-power in the internal combustion engine."[8] More power is the glaring headline here, but it's far from the only advantage. Turbo engines can make the same power as a normally-aspirated engine while using less fuel. Hence why Ford, for example, has replaced the old 1.6-litre petrol engine with a new 1.0-litre turbo – it makes the same power but uses much less fuel. Turbos also give engines more torque – often lower down in the rev range. This means they feel much stronger around town where the extra torque makes nipping

[6] According to:Turbo: Real World High-Performance Turbocharger Systems (Jay. K. Miller), pp 56-58, 22.05.2016.
[7] »https://www.carwow.co.uk/guides/glossary/how-turbos-work-superchargers-explained«, 22.05.2016.
[8] Ibid: Turbo: Real World High-Performance Turbocharger Systems (Jay. K. Miller), 22.05.2016.

into gaps easier. Another, unexpected, advantage is that turbos actually make for a quieter engine as they muffle the sound of the intake.[9]

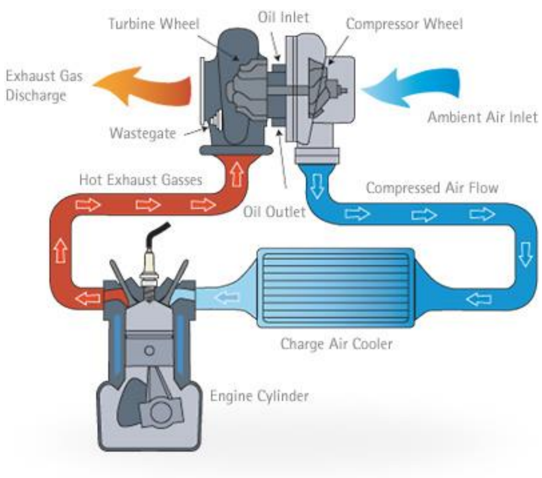
2.3.3. Downsides of turbochargers

There are not many, which is why they are so common in engines now. Mainly, they add cost and complexity to an engine – becoming just another part to go wrong – and, with the high temperatures and pressures they operate at, when they do, it is often in quite a spectacularly expensive fashion.

There is another thing. Reviewers often talk of turbo lag – a brief delay between pressing the throttle and the engine making power. This is caused when the exhaust gasses are not at the required pressure to spin the turbine optimally, hence the delay as the turbo comes 'on boost'. Car makers try to mitigate this by using smaller turbos instead of one big one, turbos with multiple optimum operating speeds or, for some race cars, a fearsome anti-lag system that causes 10ft flames to shoot out the back of the car!

Careful control of the throttle in a turbo car is required if driver wants to get close to the claimed efficiency figure – turbos are efficient when cruising 'off boost' (when the turbo isn't really working) but very inefficient when 'on boost'. This means that driver may need to alter his driving style if he is coming from a non-turbo car.[10]

Figure 2. Turbocharging system



https://straightlineconcepts.files.wordpress.com/2011/09/howturboworks.jpg, 23.05.2016.

[9] »https://www.carwow.co.uk/guides/glossary/how-turbos-work-superchargers-explained«, 23.05.2016.
[10] »https://www.carwow.co.uk/guides/glossary/how-turbos-work-superchargers-explained«, 23.05.2016.

3. LIGHTWEIGHT MATERIALS

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance. Because it takes less energy to accelerate a lighter object than a heavier one, lightweight materials offer great potential for increasing vehicle efficiency. A 10% reduction in vehicle weight can result in a 6%-8% fuel economy improvement. Replacing cast iron and traditional steel components with lightweight materials such as high-strength steel, magnesium (Mg) alloys, aluminium (Al) alloys, carbon fibre, and polymer composites can directly reduce the weight of a vehicle's body and chassis by up to 50 percent and therefore reduce a vehicle's fuel consumption.

By using lightweight structural materials, cars can carry additional advanced emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. While any vehicle can use lightweight materials, they are especially important for hybrid electric, plug-in hybrid, and electric vehicles. Using lightweight materials in these vehicles can offset the weight of power systems such as batteries and electric motors, improving the efficiency and increasing their all-electric range. Alternatively, the use of lightweight materials could result in needing a smaller and lower cost battery while keeping the all-electric range of plug-in vehicles constant.[11]

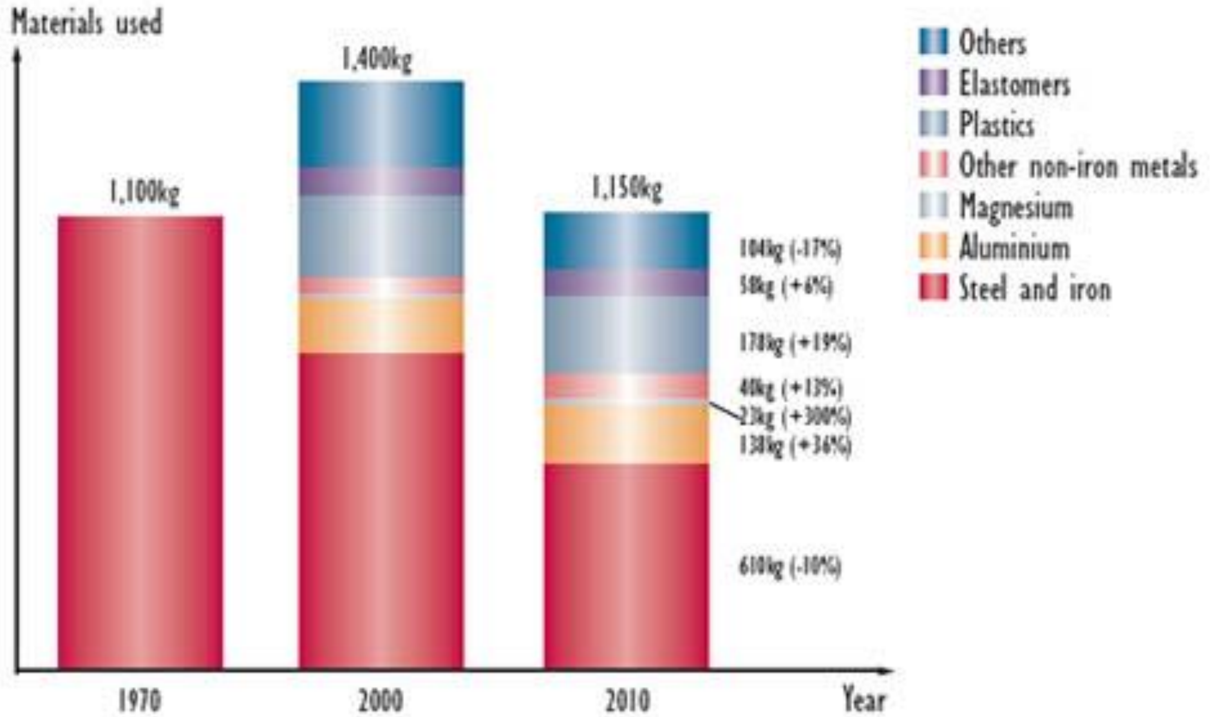
3.1. Significant improvements

The weight of a vehicle can be substantially reduced by replacing some of its parts originally manufactured in metal (typically steel) by others manufactured out of composite materials and plastics or lighter weight metals such as aluminium, magnesium, and titanium. It is easy to see the development in the Figure 3. Making a car one pound lighter actually makes it about a pound and a half lighter, because it needs lighter structure and suspension to support that weight, a smaller engine to move it, smaller brakes to stop it, and less fuel to run the engine. By using lightweight materials, manufacturers can build more fuel efficient vehicles, however, the safety and crashworthiness of a lighter weight vehicle remains a significant consideration.

[11]»http://energy.gov/eere/vehicles/vehicle-technologies-office-lightweight-materials-cars-and-trucks«, 24.05.2016.

In addition to the development of completely new materials for a given application, the industry trends reveal continual gradual improvement in the properties of the materials that have been traditionally used. This is evident by the continued development of new steel alloys for vehicle shells. New high strength low alloy steels offer considerable weight savings over traditional alloys.[12]

Figure 3. Materials usage in production of average mid-sized car



http://www-personal.umich.edu/~weberg/images/carmaterials.jpg, 24.05.2016.

3.2. Research and development

Research and development into lightweight materials is essential for lowering their cost, increasing ability to be recycled, enabling their integration into vehicles, and maximizing their fuel economy benefits.

The Vehicle Technologies Office (VTO) works to improve these materials in four ways:

1) Increasing understanding of the materials themselves through modelling and computational materials science

[12] »http://www-personal.umich.edu/~weberg/vehicle_design_material.htm«, 24.05.2016.

2) Improving their properties (such as strength, stiffness, and ductility)
3) Improving their manufacturing (material cost, production rate, or yield)
4) Developing alloys of advanced materials

In the short term, replacing heavy steel components with materials such as high-strength steel, aluminium, or glass fibre-reinforced polymer composites can decrease component weight by 10-60 percent. Scientists already understand the properties of these materials and the associated manufacturing processes. Researchers are working to lower their cost and improve the processes for joining, modelling, and recycling these materials.[13]

3.3. Carbon fibre

Carbon-fibre composites (also called carbon-fibre reinforced plastics or CFRP) are finding their way into new applications as industries demand materials with ever-higher strength-to-weight ratios, corrosion resistance, and workability. Over the past 60 years, CFRPs have been increasingly used to replace metal in applications where light weight has outsized value (capable of supporting prices that can reach $140/lb), primarily for reducing fuel consumption.

CFRPs face a divided path: well established in high-value sectors such as sporting goods, aerospace, military, and supercars, but priced out of most large-volume markets, particularly the mainstream automotive industries.

This will continue until emerging methods and materials speed up CRFP production and bring down the high prices.[14]

[13] »http://energy.gov/eere/vehicles/vehicle-technologies-office-lightweight-materials-cars-and-trucks«, 25.05.2016.
[14] »http://machinedesign.com/contributing-technical-experts/will-carbon-fiber-find-widespread-use-automotive-industry«, 25.05.2016.

4. ACTIVE SAFETY FEATURES

Active safety features are those that help to prevent or mitigate road crashes. Unlike passive safety features – which are designed to protect vehicle occupants once a crash has occurred – active safety features will engage to either prevent the crash from occurring, or reduce the severity of an unavoidable crash.

There are several ways that active safety features can help prevent crashes. Some features like forward collision warning systems and lane departure warning systems activate a warning system when potentially dangerous situations are detected. Other safety features like electronic stability control, anti-lock braking systems, and brake assist monitor the vehicle's tires and brake systems for any signs that tailored braking is necessary in order to avoid a collision. Other active safety features work as failsafe measures to protect against driver errors. For example, brake override engages to deactivate the accelerator pedal in the event that both the gas and the brake pedal are pushed down simultaneously.

What all active safety features have in common is that they constantly monitor one or more aspects of the vehicle for potential hazards. These features work silently in the background, checking the rotation speed of the tires, the location of the vehicle within its lane, or the position of the gas and brake pedals relative to each other. When something problematic is detected, active safety features act autonomously to correct the situation safely.

Active safety features offer an extra layer of protection on the road. While they cannot replace a safe and attentive driver, these features can be relied on to engage when they are most needed.[15]

4.1. Vision systems

4.1.1. ACC

Adaptive Cruise Control (ACC) is similar to traditional cruise control in that ACC keeps the vehicle's pre-set speed automatically. The biggest difference between the two, however, is that ACC can also automatically adjust the vehicle's speed to keep a pre-set distance from vehicles up ahead. For example, if the vehicle ahead slows down, or if another vehicle comes

[15] »http://brainonboard.ca/safety_features/active_safety_features.php«, 26.05.2016.

into the lane, the ACC sends a signal to the engine or brake system to slow down to keep the pre-set distance. When the road is clear again, the ACC will accelerate the vehicle up to both the pre-set speed and distance.[16]

There is also Queue Assist, also known as Stop-and-Go as an Adaptive Cruise Control Feature. Queue Assist takes control of braking and acceleration in slow-moving traffic, making driving more comfortable.

4.1.2. Blind spot monitoring

Most drivers have experienced that sense of panic from almost swerving into another car that just wasn't visible. Blind spot monitoring avoids this by alerting the driver when another vehicle enters its blind spot. In some systems the vehicle will even steer itself away from the approaching vehicle to prevent the accident.

Blind spot monitoring systems use cameras or radar to watch the area around the vehicle and look for other vehicles that are nearby. In most systems, a light will appear in the side-view mirror to alert the driver that a vehicle is present. If the driver activates the turn signal while another vehicle is in the blind spot, an audible alert or steering wheel vibration is activated.[17]

4.1.3. Forward collision warning and braking

By continuously monitoring the area in front of the vehicle, the Forward Collision Warning and Braking system detects slow-moving vehicles or other objects that the driver might hit if not noticed in time. In such cases, the system first alerts the driver with a warning signal. At the same time, the reversible active seatbelt tightens, removing any slack. The brakes are then put into "alert mode," which makes braking easier by reducing the brake's activation threshold if the driver steps on the brake pedal. And if the driver still does not react to the warning and a crash is about to happen, full braking power is automatically activated. The procedure may be seen in the Figure 4. Pedestrian Detection system works in the same way.[18]

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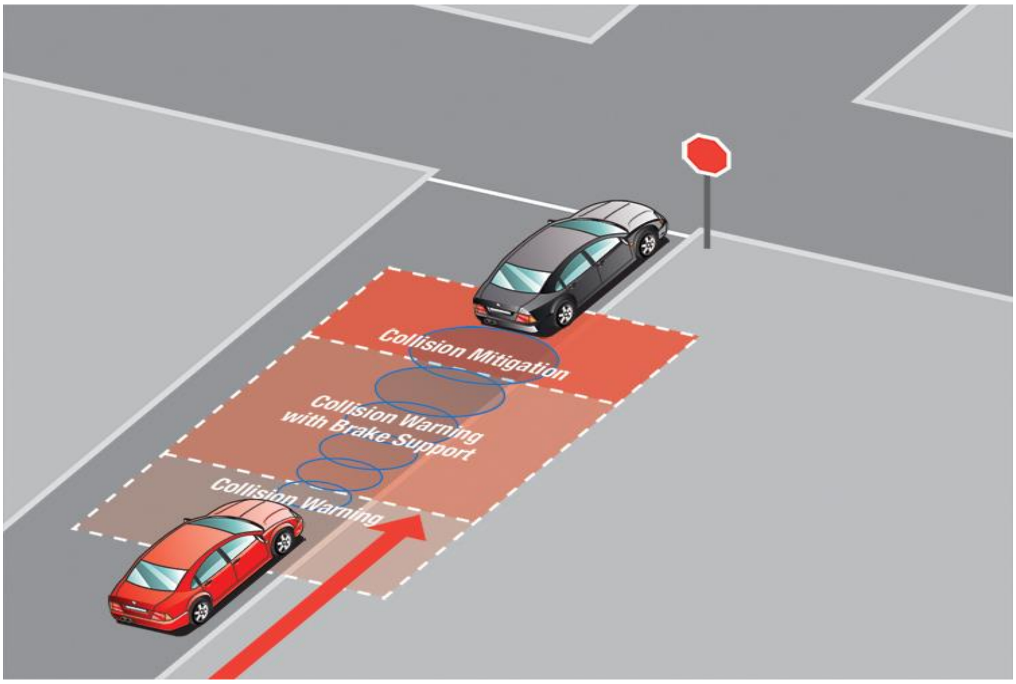
[16] »https://www.autoliv.com/ProductsAndInnovations/ActiveSafetySystems«, 26.05.2016.
[17] »https://www.cartelligent.com/blog/should-your-new-car-have-blind-spot-monitoring«, 26.05.2016.
[18] »https://www.autoliv.com/ProductsAndInnovations/ActiveSafetySystems«, 26.05.2016.

Figure 4. Collision warning and braking system



http://www.tc.gc.ca/media/images/roadsafety/7CMS.jpg, 26.05.2016.

4.2. Night vision systems

The Night Vision system displays an image of the road scene ahead that headlights might not pick up. Using infrared technology the system analyses the content of the scene while taking the vehicles' motion into account. If a pedestrian is at risk of being hit, warnings are signalled with enough time for the driver to react. The system can detect pedestrians up to two times farther than the typical headlight range.[19]

4.2.1. Passive night vision

They measure the heat generated by living objects without the need for additional illumination. Warmer objects show up as lighter images on the car's LCD, colder objects show up as dark. In between dark greys are the road and rocks emitting heat from the sun into the evening hours. It's a bit like looking at a photographic negative.

[19] »https://www.autoliv.com/ProductsAndInnovations/ActiveSafetySystems«, 26.05.2016.

Passive night vision wins hands down for claimed range, up to 1,000 feet or 300 meters. Passive systems work better in rainy and foggy conditions. The majority of cars use passive sensors. On the downside, passive systems work less effectively at warmer temperatures.[20]

4.2.2. Active night vision

Active night vision systems use an infrared illuminator, sometimes part of the headlamp cluster, to light up the road in the IR spectrum. The image can be higher-resolution than passive. Roads and buildings show up better. That's why drivers initially think they're watching black and white TV of the road ahead.

With active night vision, it's possible to mount the camera higher in the car, in the rear view mirror cluster, for a better view. As with normal headlamps, the range of active night vision systems is reduced in rain, snow or fog, and effectiveness falls off with the square of the distance. The lifelike image might induce some drivers to think they can steer by the night vision display alone; it's just not possible except maybe for a few seconds on country roads where the illuminator clearly shows the pavement centreline and edge markings.

Some automakers employ a fusion method for night vision, like in the Figure 5. joining passive and active systems. Currently Mercedes-Benz does that. The display is typically a positive not negative monochrome image.[21]

Figure 5. Combination of active and passive night vision

http://www.eagleeyeuk.com/wp-content/uploads/2016/04/might-vision.jpg, 27.05.2016.

[20] »http://www.extremetech.com/extreme/193402-what-is-night-vision-how-does-it-work-and-do-i-really-need-it-in-my-next-car«, 26.05.2016.
[21] »http://www.extremetech.com/extreme/193402-what-is-night-vision-how-does-it-work-and-do-i-really-need-it-in-my-next-car«, 27.05.2016.

4.3. Stability and braking

4.3.1. ABS

An anti-lock braking system (ABS) is a system on motor vehicles which prevents the wheels from locking while braking. The purpose of this is to allow the driver to maintain steering control under heavy braking and, in some situations, to shorten braking distances (by allowing the driver to hit the brake fully without the fear of skidding or loss of control). Disadvantages of the system include increased braking distances under certain conditions and the creation of a "false sense of security" among drivers who do not understand the operation and limitations of ABS.[22]

An ABS system consists of the following components (all shown in the Figure 6.):

1) Some wheel speed sensors

2) Brake callipers

3) A hydraulic motor

4) Some pressure release valves

5) A quick thinking computer (or control module) which coordinates the whole process

How it works?

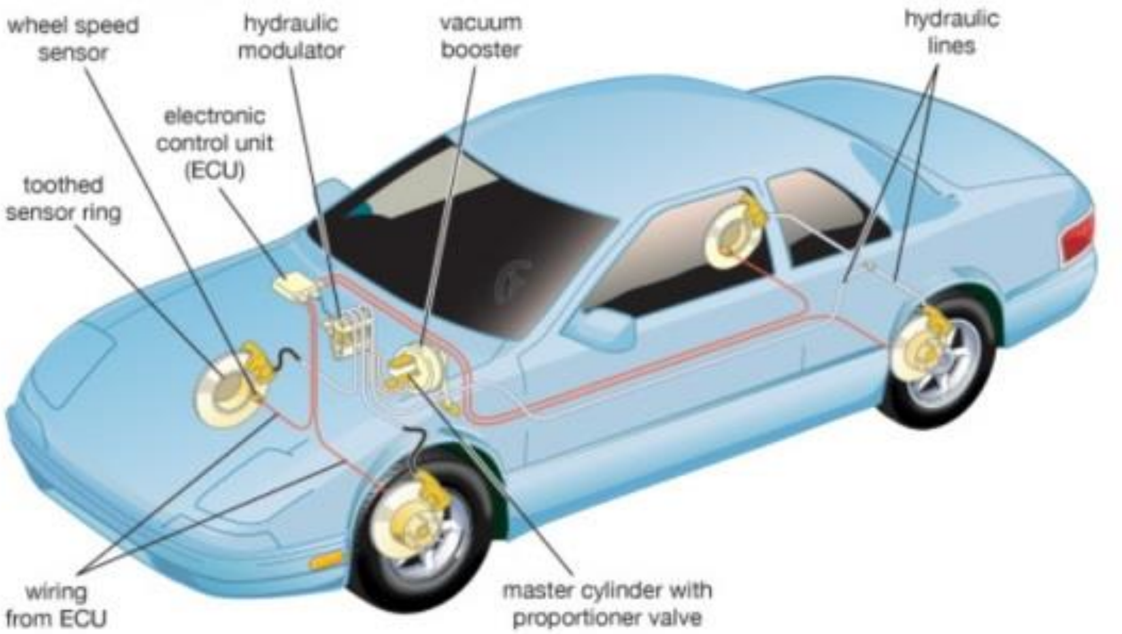
When the driver hits the brakes this pressurises a hydraulic system which causes the brake pads to squeeze against the discs which causes the car to slow down. If the ABS system detects that one wheel is slowing down more rapidly than the rest (a symptom of wheel-lock) it automatically reduces the brake pressure on this wheel by opening a pressure release valve in the hydraulic system. ABS also has the ability to build the pressure back up via the hydraulic motor. The system reacts remarkably quickly, and compared wheel speeds many times a second. ABS systems can act on just the front wheels (which do most of the braking work), or all four depending on what car you're driving.

[22] »http://www.absbrakes.co.uk/absoperation.html«, 28.05.2016.

Three versus four channel systems

There are two main types of modern ABS systems: three and four channel. Three channel systems control the braking pressure on both front wheels independently, but control the rear wheels together as a single unit. Four channel systems control the brake force on each wheel independently (assuming driver is in a four wheeled vehicle!). In three channel systems, although both rear wheels are monitored by sensors, if wheel lock if detected on a single wheel the hydraulic braking pressure is reduced equally on both wheels. This does not provide the level of control of a four channel system, and thus three channel versions are compromised and usually only fitted to cars to save on cost. Most modern cars now use a four channel ABS systems which provide greater safety in emergency braking conditions.[23]

Figure 6. ABS



http://automotivesuperconference.net/wp-content/uploads/2015/11/anti-lock-braking-system-ABS.jpg, 28.05.2016.

[23] »http://www.drivingfast.net/technology/abs.htm«, 28.05.2016.

4.3.2. Traction control system

Traction control is an active vehicle safety feature designed to help vehicles make effective use of all the traction available on the road when accelerating on low-friction road surfaces. When a vehicle without traction control attempts to accelerate on a slippery surface like ice, snow, or loose gravel, the wheels are liable to slip. The result of wheel slip is that the tires spin quickly on the surface of the road without gaining any actual grip, so the vehicle does not accelerate. Traction control activates when it senses that the wheels may slip, helping drivers make the most of the traction that is available on the road surface. Great example of TCS benefit may be seen in the Figure 7.

It is important to remember that traction control cannot create traction where there is none. On a truly frictionless surface, like ice, vehicles with traction control would perform just as poorly as vehicles without it.[24]

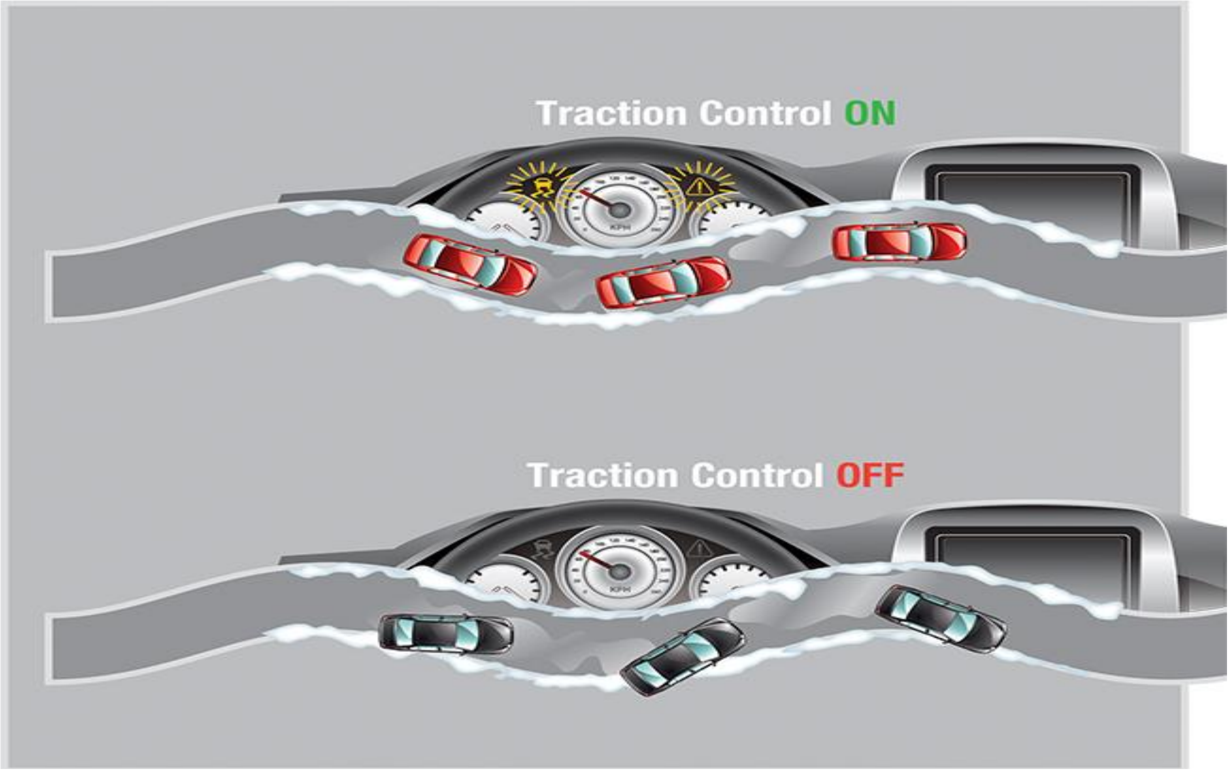
How traction control operates?

Modern vehicles feature electronic traction control, which includes the use of sensors that are used in the ABS system. These wheel speed sensors monitor the speed of the wheels and determine if one or more have lost traction. If the sensors recognize that one wheel is turning faster than all of the others, it uses the brake connected to that wheel to slow it down. This is generally enough to slow the vehicle down and allow the driver to regain control.

Some vehicles are equipped to take the process one step further. They may reduce the power of the engine that is going to the wheels. You often feel the gas pedal pulsating at this time. Traction control has been around for several years and is seen in many of today's models. An early version of the system was seen on rear-wheel drive vehicles and was called a limited slip rear differential.[25]

[24] »http://brainonboard.ca/safety_features/active_safety_features_traction_control.php«, 29.05.2016.
[25] »https://www.yourmechanic.com/article/how-does-traction-control-work«, 29.05.2016.

Figure 7. Traction Control benefit



http://www.bobbellnissan.com/blogs/729/wp-content/uploads/2015/02/4TC.jpg, 29.05.2016.

4.3.3. Electronic stability control

Electronic Stability Control (ESC) helps drivers to avoid crashes by reducing the danger of skidding, or losing control as a result of over-steering. ESC becomes active when a driver loses control of their car. It uses computer controlled technology to apply individual brakes and help bring the car safely back on track, as it is presented in the Figure 8.

How does it work?

ESC works by using a number of intelligent sensors that detect any loss of control and automatically apply the brake to the relevant wheel, putting your car back on the intended path. ESC is of assistance to the driver in:

1) correcting impending oversteering or understeering;
2) stabilising the car during sudden evasive manoeuvres;
3) enhancing handling on gravel patches;
4) such as road shoulders;
5) improving traction on slippery or icy roads.

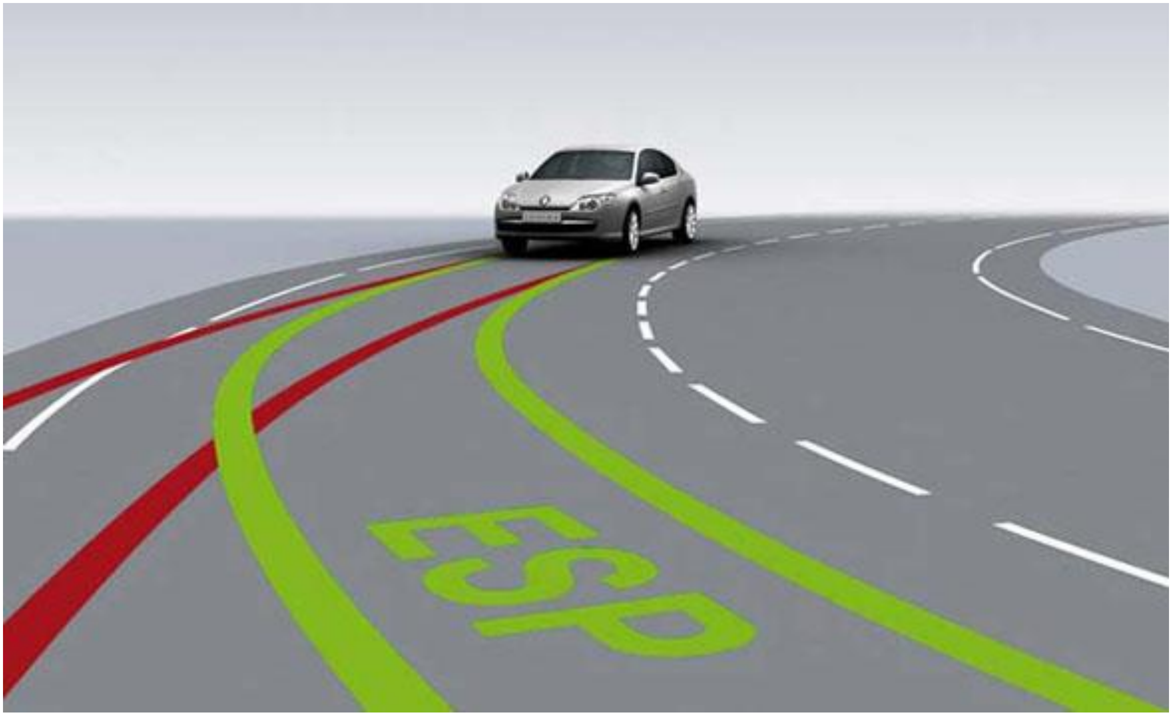
Not all ESC systems are identical. The hardware is similar, but there are variations in how ESC systems are programmed to respond once loss of control is detected.

Naturally, the degree of effectiveness of ESC is dependent upon the amount of traction between the road and the car. Therefore on a car with old, worn or inappropriate tyres, ESC will be less effective than on a car with new tyres or tyres specific to a road environmental condition.

ABS and TCS integration

ABS and Traction control are integral components of an ESC system. Whilst every car with ESC has ABS and Traction Control, those with ABS and Traction control do not necessarily have ESC. ABS and Traction Control only work in the driving (longitudinal) direction. ESC can help drivers to cope with sideways (lateral) movements which create instability. Unlike ABS and Traction Control, ESC is a holistic system that can control a car's entire movements.[26]

Figure 8. ESP



http://revistacadam.com/wp-content/uploads/2011/04/esp-car.jpg, 30.05.2016.

[26] »http://www.howsafeisyourcar.com.au/Electronic-Stability-Control/«, 30.05.2016.

5. PASSIVE SAFETY FEATURES

“Passive safety refers to features that help to protect vehicle occupants during and after crash. To this category belong components, such as seat belts, airbags, physical structure of the vehicle, and energy absorbing materials.”[27] [30] Unlike active safety features – which aim to prevent before or mitigate crashes when they do happen – the main function of passive safety features is to keep the driver and passengers protected within the vehicle from various crash forces.

Modern vehicles contain what engineers sometimes refer to as a life space. The life space is a protected area around vehicle occupants within which the chances of escaping a crash with minimal injuries are more likely. Passive safety features work to ensure that this life space is as safe as possible, and that vehicle occupants remain in this space throughout the crash. Crumple zones help to absorb and distribute crash forces before they reach the passenger and driver’s seats. Similarly, seatbelts, airbags, and headrests help keep the driver and passenger(s) stationary within the life space of the vehicle. Safety features like these reduce the risk of serious injury and allow drivers and passengers to ride out a crash.

The area outside of the life space is where more severe injuries may be unavoidable. For example, if a driver involved in a crash fails to wear his seatbelt, he may be projected outside of the life space of the vehicle, striking the windshield or other parts of the vehicle’s hard interior. In the event of a more forceful crash, the un-belted driver is often completely ejected from the vehicle.

Despite the classification of these features as “passive”, they are extremely important when it comes to reducing the severity of crash injuries. These features are also constantly being developed and refined. For example, in many new vehicles, airbags do not just inflate out of the steering column but also appear along the side-panels and even around the knees. Advanced seatbelts are also available that can moderate the amount of tension across a person’s body, so as to reduce instances of seatbelt-related injuries. Even headrests can include passive safety technology in order to reduce the risk of whiplash.[28]

[27] According to: Wireless vehicular networks for car collision avoidance (Rola Naha), 31.05.2016.
[28] »http://brainonboard.ca/safety_features/passive_safety_features.php«, 31.05.2016.

5.1. Crumple zones

Auto safety has come a long way in the last few decades, and one of the most effective innovations is the crumple zone. Also known as a crush zone, crumple zones are areas of a vehicle that are designed to deform and crumple in a collision. This absorbs some of the energy of the impact, preventing it from being transmitted to the occupants.

Of course, keeping people safe in auto accidents is not as simple as making the whole vehicle crumple. Engineers have to consider many factors in designing safer cars, including vehicle size and weight, frame stiffness and the stresses the car is likely to be subjected to in a crash. For example, race cars experience far more severe impacts than street cars, and SUVs often crash with more force than small cars.[29]

5.1.1. How does a crumple zone work?

As explained in the introduction, a crumple zone helps to redistribute the force of an impact on a vehicle. This is achieved by crafting the front and rear of the vehicle from a material that is designed to bend or collapse into itself upon impact. Often, engineers will have to compromise between using a material that offers too little resistance to force and too great a resistance to force.

Newton's Second Law of Motion states that force is equal to mass multiplied by acceleration. This means that acceleration and force are proportionate, e.g. if the acceleration is halved, the magnitude of force will also be halved. Using this knowledge, the crumple zone is designed to reduce the magnitude of deceleration of a vehicle, so that the force exerted on the vehicle is also reduced.

The ability of a crumple zone to collapse when a force is applied to it helps to increase the time taken for the vehicle to come to a complete stop. Since acceleration is equal to $(v-u)/t$, where v denotes final velocity, u denotes initial velocity and t denotes time, increasing the time taken causes the magnitude of deceleration of the vehicle to be reduced.

It is crucial to make very precise tests of crumple zones with method of car crash testing, like in the Figure 9.

[29] »http://auto.howstuffworks.com/car-driving-safety/safety-regulatory-devices/crumple-zone.htm« 01.06.2016.

Dependent on the type of vehicle being manufactured, the crumple zone can be constructed to withstand a large impact, typical of a racing vehicle, or to withstand a small impact, such as one experienced by a small road vehicle.[30]

5.1.2. What about very small cars?

That is a very good question as small cars do not have room for crumple zones. Take the smart for instance. Where could you possibly have crumple zones on a car like that? Engineers found a solution for that minute vehicle as well.

All generations of the smart are built around a tridion safety cell, a steel housing that combines longitudinal and transverse members that displace impact forces over a large area of the car.[31]

Figure 9. Car crash testing

https://sites.google.com/site/uavjw861/_/rsrc/1353070215264/crumple-zones/Screen%20Shot%202012-11-16%20at%2012.43.14.png, 01.06.2016.

[30] »https://sites.google.com/site/uavjw861/crumple-zones/how-does-a-crumple-zone-work«, 01.06.2016.
[31] »http://www.autoevolution.com/news/how-crumple-zones-work-7112.html«, 01.06.2016.

5.2. Airbag

Twenty years ago, when vehicle airbag systems were first being offered, many people joked about how airbags worked. Some likened them to stove-top popcorn, of the type that started out looking like a pie pan and ended up looking like a lumpy silver balloon, while others thought they were just really big balloons. Either way, most people thought and many people still think that once an airbag deploys, it remains inflated leaving a driver cheek to cheek with talcum coated nylon until help arrives.

In reality though, how airbags work is by decreasing the momentum of the driver and passengers within a car to zero. It is a direct relation to the old physics statement about objects in motion remaining in motion; when a car collides with another, the car stops moving but without an airbag and a seatbelt (they are designed to work together) person would keep going forward. To make matters more difficult, this momentum must be stopped in less than a whole second and only the space between the driver and steering wheel or passenger and dashboard is available for this to happen.[32]

5.2.1. How do airbags work?

There are three main components to an airbag system. They are the bag, the sensor, and the inflation system.

Airbags are constructed from a fine gauge of nylon and then folded into the steering wheel, dashboard, the door panel or sometimes, the roof rails above the door.

This is the mechanism that tells the bag it is time to inflate, which generally requires the equivalent force of running into a brick wall at 10 - 15 mph. Sensors in newer airbag systems are designed to determine whether or not there is a person in the front passenger seat and whether or not the passenger has enough weight for the bag to be safely deployed.

The inflation system of an airbag is usually a combination of potassium nitrate (KNO3) and sodium azide (NaN3) which combine to form nitrogen gas. Hot discharges of this gas inflate the bag at a speed of roughly 200 mph. Immediately after inflation, the gas is dispersed

[32] »http://www.topspeedracer.com/how-airbags-work.html«, 02.06.2016.

through tiny holes in the airbag, which causes it to deflate. The entire process takes about 1/25 of a second.[33]

5.2.2. Pedestrian airbag

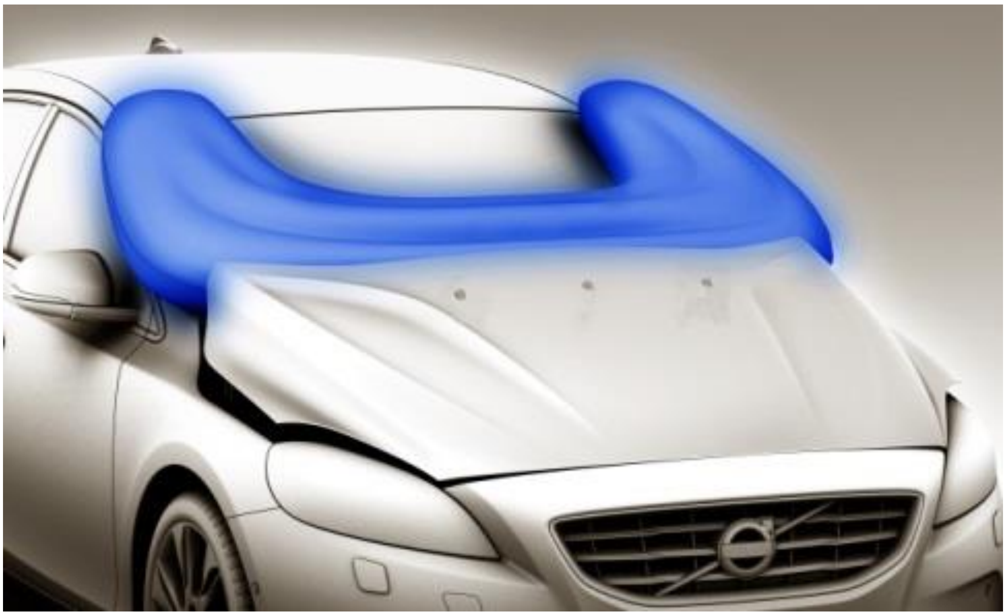
Volvo, the Swedish carmaker known for its safety engineering introduced the first car airbag for pedestrians and it is shown in the Figure 10.

The airbag for pedestrians (Pedestrian Airbag) contributes in certain frontal collisions to alleviating the collision of the pedestrian with the car.

The pedestrian airbag (Pedestrian Airbag) is fitted under the bonnet near the windscreen. In the event of certain frontal collisions with a pedestrian, the sensors in the front bumper react and the airbag inflates if required, based on the force of the impact. The sensors are active at a speed of approx. 20-50 km/h and an ambient temperature between -20 and +70°C.

The sensors are designed to detect a collision with an object that has similar properties to those of the human leg.[34]

Figure 10. Pedestrian airbag



http://funkeeper.net/wp-content/uploads/2014/07/Exterior-airbags.jpg, 02.06.2016.

[33] »http://www.topspeedracer.com/how-airbags-work.html«, 02.06.2016.

[34] »http://support.volvocars.com/uk/cars/Pages/owners-manual.aspx?mc=y555&my=2015&sw=14w20&article=7fceb4e7544b4fbbc0a801e800b0ef6b«, 02.06.2016.

5.3. eCALL

On April 28, 2015, the European Parliament voted in favour of an eCall regulation, which requires all new models of passenger cars and light vans that will be certified for the European market to be equipped with the automated emergency-call technology beginning in April 2018. The measure applies to all such vehicles regardless of selling price. In the future, a similar service may be implemented for trucks as well.

eCall was developed to address the problem that drivers involved in accidents often have inaccurate awareness of their location, especially on interurban roads or abroad. In the most crucial cases, victims may not be able to call because they have been injured or trapped, and no witnesses or passers-by may be around to assist them.

The eCall system, which provides the exact location of an accident and requires no subscription, will bring emergency services to crash victims as quickly as possible. In the event of a serious accident, eCall automatically dials 112, Europe's single emergency number.[35] The whole procedure may be seen in the Figure 11.

5.3.1. Privacy concerns

In drafting the eCall regulation special attention was given to the many concerns arising from the processing of data related to individuals. The European Commission has taken all necessary measures to safeguard privacy of the vehicles' occupants, after consulting with data protection authorities and the European Data Protection Supervisor office.

The main fear was that, by having an eCall equipment installed in their vehicles, people will be continuously tracked, their driving behaviour monitored, and, ultimately, their privacy violated.

Data sent by the in-vehicle equipment should be limited to the minimum information required to appropriately handle emergency calls. The in-vehicle system will continuously erase data on previous locations of the vehicle. No intermediate parties, including the mobile operators, have access to this minimum information that is transmitted from the in-vehicle system.[36]

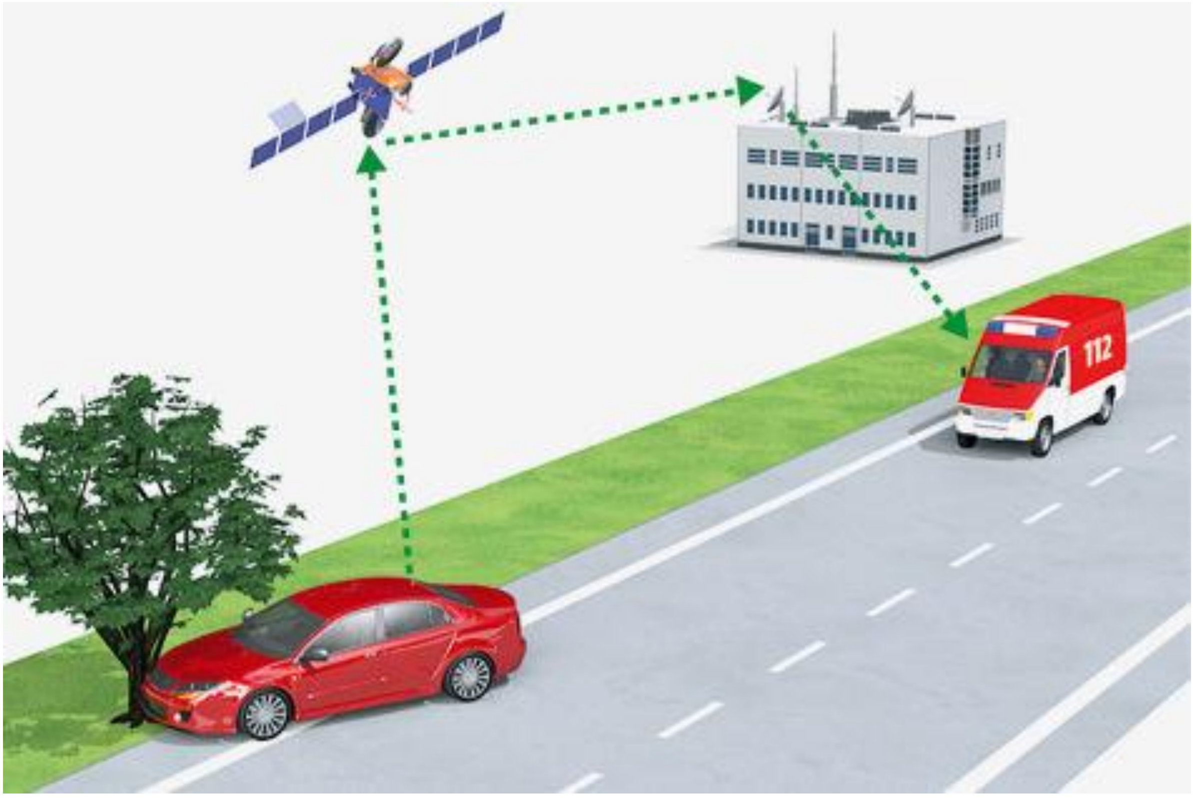
[35] »http://www.insidegnss.com/node/4720«, 03.06.2016.
[36] »http://www.insidegnss.com/node/4720«, 03.06.2016.

5.3.2. Expected Benefits and Business Opportunities

The first and most important reason that pushed the EU towards adoption of emergency call capability in every new car on the road is the expected reduction of accident fatalities. Estimates suggest that eCall could save up to 2,500 direct fatalities annually in Europe when fully deployed, while improving the treatment outcomes of non-fatal injuries and the associated human suffering. Emergency calls made from vehicles or mobile telephones using wireless technologies can help achieve these objectives.

In hard financial terms, eCall could improve emergency response times by as much as 50 percent (50 percent faster in rural areas, 40 percent in urban areas) and thus reduce car accident fatalities and mitigate the associated injuries. This would save European taxpayers billions of euros annually (up to €20 billion a year, according to some studies). Further benefits can be expected from the reduction of traffic congestion caused by accidents, thus cutting fuel waste and lowering carbon monoxide, carbon dioxide, and other harmful emissions.[37]

Figure 11. eCALL system



http://i.auto-bild.de/ir_img/1/1/7/9/5/3/6/eCall-Grafik-474x316-5adf5e303ce9fdfe.jpg, 03.06.20116.

[37] »http://www.insidegnss.com/node/4720«, 03.06.2016.

6. ELECTRONIC POWER STEERING

Power steering systems supplement the torque that the driver applies to the steering wheel. Traditional power steering systems are hydraulic systems, but electric power steering (EPS) is becoming much more common. EPS eliminates many HPS components such as the pump, hoses, fluid, drive belt, and pulley. For this reason, electric steering systems tend to be smaller and lighter than hydraulic systems.

EPS systems have variable power assist, which provides more assistance at lower vehicle speeds and less assistance at higher speeds. They do not require any significant power to operate when no steering assistance is required. For this reason, they are more energy efficient than hydraulic systems.[38]

6.1. How does the system work?

As it is perfectly described in the Figure 12:

1) The EPS electronic control unit (ECU) calculates the assisting power needed based on the torque being applied to the steering wheel by the driver, the steering wheel position and the vehicle's speed.

2) The EPS motor rotates a steering gear with an applied force that reduces the torque required from the driver.

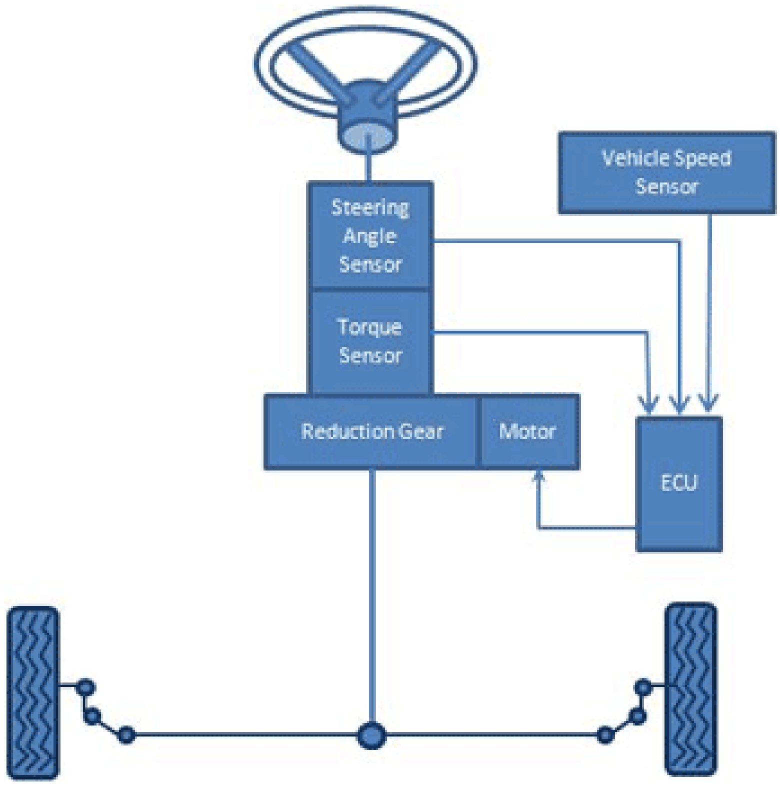
There are four forms of EPS based on the position of the assist motor. They are the column assist type (C-EPS), the pinion assist type (P-EPS), the direct drive type (D-EPS) and the rack assist type (R-EPS). The C-EPS type has a power assist unit, torque sensor, and controller all connected to the steering column. In the P-EPS system, the power assist unit is connected to the steering gear's pinion shaft. This type of system works well in small cars. The D-EPS system has low inertia and friction because the steering gear and assist unit are a single unit. The R-EPS type has the assist unit connected to the steering gear. R-EPS systems can be used on mid- to full-sized vehicles due to their relatively low inertia from high reduction gear ratios.[39]

[38] »http://www.cvel.clemson.edu/auto/systems/ep_steering.html«, 04.06.2016.
[39] »http://www.cvel.clemson.edu/auto/systems/ep_steering.html«, 04.06.2016.

6.2. Steer by wire

The next step in electronic steering is to remove the mechanical linkage to the steering wheel and convert to pure electronically controlled steering, which is referred to as steer-by-wire. This functions by transmitting digital signals to one or more remote electric motors instead of a rack and pinion assembly, which in-turn steers the vehicle. While it has been used in electric forklifts and some tractors, as well as a handful of concept cars, the 2014 Infinity Q50 was the first commercial vehicle to implement steer-by-wire. Although there is normally no direct mechanical linkage, the Q50 has a mechanical back-up. In the event that a problem is detected with the electronic controls, a clutch engages to restore the driver's mechanical control. As with throttle control systems, it is likely that steer-by-wire will become the standard once the electronic controls prove to be safer and more reliable than the current hybrid systems.[40]

Figure 12. EPS system



http://www.cvel.clemson.edu/auto/systems/images/ali-steering.png, 04.06.2016.

[40] »http://www.cvel.clemson.edu/auto/systems/ep_steering.html«, 04.06.2016.

7. GPS NAVIGATION

A GPS Navigation is a GPS system invented for the orientation of a driver in unknown places. It is produced in a few types, car-based (Figure 13.) or hand-held device or a smartphone app.

7.1. GPS Development

Like most technology, the Global Positioning System (GPS) was originally created for military use and has only recently become available to civilians. The first GPS satellite was actually launched back in 1978. Since that time, they've created a constellation of satellites orbiting the earth. Over 50 satellites have been launched, but only approximately 30 are active. The GPS satellites need to be replaced every 10 years or so.

Each one of these GPS satellites can orbit the globe twice a day. As they travel, they send out a low-power radio signal to the earth below. GPS navigation unit receives this signal and measures the time it took for the signal to get from the satellite to the receiver. The arrangement of their orbits ensures that you'll always have a satellite ready to send a signal too receiver.[41]

Figure 13. GPS navigation system in car

http://economictimes.indiatimes.com/photo/11753505.cms, 05.06.2016.

[41] »http://in-dash-navigation-review.toptenreviews.com/gps-navigation-how-does-it-work.html«, 05.06.2016.

7.2. How does GPS work?

Satellite navigation systems all work in broadly the same way. There are three parts: the network of satellites, a control station somewhere on Earth that manages the satellites, and the receiving device.

“The fundamental technique of GPS is to measure the ranges between the receiver and a few simultaneously observed satellites.”[42]

Each satellite is constantly beaming out a radio-wave signal toward Earth. The receiver "listens out" for these signals and, if it can pick up signals from three or four different satellites, it can figure out user precise location (including altitude).

The satellites stay in known positions and the signals travel at the speed of light. Each signal includes information about the satellite it came from and a time-stamp that says when it left the satellite. Since the signals are radio waves, they must travel at the speed of light. By noting when each signal arrives, the receiver can figure out how long it took to travel and how far it has come—in other words, how far it is from the sending satellite. With three or four signals, the receiver can figure out exactly where it is on Earth.[43]

[42] According to: GPS: Theory, Algorithms and Applications (Guochang Xu), 05.06.2016.
[43] »http://www.explainthatstuff.com/howgpsworks.html«, 05.06.2016.

8. HUD SYSTEM

Heads-Up Display (HUD) is an electronic system that superimposes vehicle information on the windshield without requiring the driver to take their eyes off the road. HUD allows drivers to keep their attention focused on the road and still receive information that would normally require a glance at the instrument panel on the dashboard.[44]

8.1. How does a heads-up display work?

Nearly all vehicle-based HUD systems use a small cathode ray tube (CRT) to project vehicle data onto a special element on the windshield. The information is typically superimposed in the lower half of the glass, as it is presented in the Figure 14; which is inside the driver's immediate line of sight. To reduce eye strain and allow faster comprehension of the information, HUD data is displayed at "infinity focus" (a focal point equal to that of the roadway in front of the vehicle). There is no need for the driver to refocus their eyes to view the HUD information. Recent advances in display technology have improved the design of most heads-up display units; many now utilize liquid crystal display (LCD) and light-emitting diode (LED) technology to offer the driver brighter images. These technologies are less expensive to manufacture, and more reliable when compared to a CRT display.[45]

Figure 14. HUD technology

http://continental-head-up-display.com/wp-content/uploads/2014/07/Head_up_display_technology_experience.jpg, 05.06.2016.

[44] »http://www.jdpower.com/cars/articles/tips-advice/heads-display-technology«, 05.06.2016.
[45] »http://www.jdpower.com/cars/articles/tips-advice/heads-display-technology«, 05.06.2016.

8.2. Typical uses of a HUD

The earliest automotive HUD systems simply projected the speed of the vehicle onto the windshield in front of the driver. Today, these systems project speed, turn signal information, high-beam indicator usage, radio status, outside air temperature, compass, and a full assortment of warning messages. Most systems allow the driver to customize the information they would like to see, or to turn the system off completely.

Advanced HUD systems provide navigation information via satellite to the driver, including turn-by-turn instructions. Collision-avoidance systems, which use infrared or low-light cameras, use HUD to superimpose an enhanced view of the roadway onto the display, offering the driver a much better view outside the vehicle during inclement weather or darkness.[46]

[46] »http://www.jdpower.com/cars/articles/tips-advice/heads-display-technology«, 05.06.2016.

9. PRACTICAL USAGE IN DRIVING SCHOOLS

Driving school is a place where people study traffic safety rules and regulations, learn how to control vehicle and give basic first aid. As cars in driving school are not allowed to be seven years old or more, it is obvious that driving schools use only modern cars with all advanced technologies.

9.1. Active safety in driving schools

There have been some changes in driver education because of implementation of newest advancements in vehicles. Instructors in driving schools have a great influence on future driver habits and behaving in traffic. They have to teach a driver how to properly use modern technologies as TCS, ABS and such, but not relaying on mentioned technologies. Studies have shown that drivers drive faster and have more confidence than should have because of these modern features in the car. Despite all the benefits from active safety features, accidents are still possible and according to driving schools, a driver is still the main safety feature in a car.

9.2. GPS navigation in driving schools

GPS navigation as a new feature in cars has not found a big place in driving schools because of a simple reason. It might have a bad influence on future drivers` driving capabilities. If a fresh driver is relaying on navigation devices, it could happen that he or she feels unsecure in some daily traffic situation without navigation device and voice guidance. Driver should learn how to drive any car, with or without advanced technologies such as GPS. That is why it is not allowed to use all the newest technologies in driving schools.

9.3. Knowledge in development

According to instructors, they must extend the licence every few years. New cars are made with new advancements so new knowledge is following them as well. Therefore it is not possible to teach fresh driver, like one in the Figure 15; to use certain technologies if an instructor is not properly educated. It is important to mention that not all the newest technologies are used in driving schools, for example parking systems are definitely not. That is still done as before, drivers should know how to park without electronic help.

Figure 15. Young driver attending car school

https://scontent-vie1-1.xx.fbcdn.net/v/t1.0-9/12472733_1598212150498170_3673846195134434557_n.jpg?oh=828950aec096da3b0c0a6d9aa7ad41f6&oe=57DE119D, 06.06.2016.

10. CONCLUSION

There have been much advancement in technology over the last few decades, an unthinkable amount of improvements to automotive technology has been made, making cars easier to drive and operate, safer, and perform better. Cars do not just get us from point to point, they offer a lot more with growing technology, they are fun to drive, they offer music, field phone calls, are our navigators, and keep us safe. Cars are the most common and efficient method of travel for short distances in the world, and it is important that people utilize the technology cars can offer. There is a vast number of new technologies available on new vehicles or top of the range vehicles that will become more common in future and there are also many more technologies being researched. Modern cars are very fast, probably even more than it is needed, but there is great importance of developing safety features, especially active safety features all of which are designed to alert, assist, or take control from, the driver, and all respond to different dangers at different intervals before an accident occurs. Because of that it is obvious that the most significant improvement happens in active safety features. In the further future, it is likely that the vehicle will use the information that it has gathered from the warning phase to intervene and prevent an accident. The final influence that a vehicle can have on an accident before it occurs is the pre-crash phase, and this is a combination of active and passive safety. There are many ways that a vehicle can use the data gathered before the crash through sensors and active safety systems. These data could be very useful for activation of passive features and eCALL system that has also been described in this work. Despite all mentioned advancements, according to drivers, there is the biggest difference made in interior. Nowadays with all available electric technologies like HUD a driver really feels sometimes like driving a spaceship. To sum up, in this work the most important features that science refers to the term of “modern car” are described. However there will be even greater inventions in the near future and cars will get even better. This thesis was aimed at researching new technologies and science development in car industry.

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