CHAPTER 1

INTRODUCTION

1.1 Overview

The overview of this project is to implement a driverless car is an autonomous vehicle that can drive itself from one point to another without assistance from a driver. One of the main impetuses behind the call for driverless cars is safety. An autonomous vehicle is fundamentally defined as a passenger vehicle. An autonomous vehicle is also referred to as an autopilot, driverless car, auto-drive car, or automated guided vehicle (AGV). Most prototypes that have been built so far performed automatic steering that were based on sensing the painted lines in the road or magnetic monorails embedded in the road.

1.2 Purpose

Purpose of the current work is to study and analyze the driverless car technology. This mobility is usually taken for granted by most people and they realize that transportation forms the basis of our civilization. The need for a more efficient, balanced and safer transportation system is obvious. This need can be best met by the implementation of autonomous transportation systems.

1.3 Scope

Current work focuses on how to use the Future Car Technology That's On the Road Today. In the future, automated system will help to avoid accidents and reduce congestion. The future vehicles will be capable of determining the best route and warn each other about the conditions ahead. Many companies and institutions working together in countless projects in order to implement the intelligent vehicles and transportation networks of the future.
CHAPTER 2

LITERATURE SURVEY

A driverless car is an autonomous vehicle that can drive itself from one point to another without assistance from a driver. Some believe that autonomous vehicles have the potential to transform the transportation industry while virtually eliminating accidents, and cleaning up the environment. According to urban designer and futurist Michael E. Arth, driverless electric vehicles—in conjunction with the increased use of virtual reality for work, travel, and pleasure—could reduce the world's 800,000,000 vehicles to a fraction of that number within a few decades. Arth claims that this would be possible if almost all private cars requiring drivers, which are not in use and parked 90% of the time, would be traded for public self-driving taxis that would be in near constant use. This would also allow for getting the appropriate vehicle for the particular need—a bus could come for a group of people, a limousine could come for a special night out, and a Segway could come for a short trip down the street for one person. Children could be chauffeured in supervised safety, DUlIs would no longer exist, and 41,000 lives could be saved each year in the U.S. alone.

Driverless passenger car programs include the 800 million EC EUREKA Prometheus Project on autonomous vehicles (1987-1995), the 2getthere passenger vehicles (using the FROG-navigation technology) from the Netherlands, the ARGO research project from Italy, and the DARPA Grand Challenge from the USA. For the wider application of artificial intelligence to automobiles see smart cars.

The control mechanism of an autonomous car consists of three main blocks as shown below.

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sensors
- laser sensors
- cameras
- radars
- ultrasonic sensors
- GPS, etc

Logic processing unit
- software
- Decision making
- Checking functionality
- User interface

Mechanical control systems
- consists of servo motors and relays
- Driving wheel control
- Brake control
- Throttle control, etc
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Most autonomous vehicle projects made use of stock cars and modified them, adding “smart” hardware to create automated cars. The advantage of using stock cars is the ease of obtaining the car through sponsors. The stocks cars help convey the message autonomous vehicles are not science fiction anymore and these systems can be implemented on normal cars.

2.1 History

An early representation of the driverless car was Norman Bel Geddes's Futurama exhibit sponsored by General Motors at the 1933 World's Fair, which depicted electric cars powered by circuits embedded in the roadway and controlled by radio.

The history of autonomous vehicles starts in 1977 with the Tsukuba Mechanical Engineering Lab in Japan. On a dedicated, clearly marked course it achieved speeds of up to 30 km/h (20 miles per hour), by tracking white street markers (special hardware was necessary, since commercial computers were much slower than they are today).

In the 1980s a vision-guided Mercedes-Benz robot van, designed by Ernst Dickmanns and his team at the Bundeswehr University of Munich in Munich, Germany, achieved 100 km/h on streets without traffic. Subsequently, the European Commission began funding the 800 million Euro EUREKA Prometheus Project on autonomous vehicles (1987–1995).

Also in the 1980s the DARPA-funded Autonomous Land Vehicle (ALV) in the United States achieved the first road-following demonstration that used laser radar (Environmental Research Institute of Michigan), computer vision (Carnegie Mellon University and SRI), and autonomous robotic control (Carnegie Mellon and Martin Marietta) to control a driverless vehicle up to 30 km/h. In 1987, HRL Laboratories (formerly Hughes Research Labs) demonstrated the first off-road map and sensor-based autonomous navigation on the ALV. The vehicle travelled over 600m at 3 km/h on complex terrain with steep slopes, ravines, large rocks, and vegetation.

In 1994, the twin robot vehicles VaMP and Vita-2 of Daimler-Benz and Ernst Dickmanns of UniBwM drove more than one thousand kilometers on a Paris three-lane highway in standard heavy traffic at speeds up to 130 km/h, albeit semi-autonomously with human interventions.
They demonstrated autonomous driving in free lanes, convoy driving, and lane changes left and right with autonomous passing of other cars.

In 1995, Dickmanns’ re-engineered autonomous S-Class Mercedes-Benz took a 1600 km trip from Munich in Bavaria to Copenhagen in Denmark and back, using saccadic computer vision and transputers to react in real time. The robot achieved speeds exceeding 175 km/h on the German Autobahn, with a mean time between human interventions of 9 km, or 95% autonomous driving. Again it drove in traffic, executing manoeuvres to pass other cars. Despite being a research system without emphasis on long distance reliability, it drove up to 158 km without human intervention.

In 1995, the Carnegie Mellon University Navlab project achieved 98.2% autonomous driving on a 5000 km (3000-mile) "No hands across America" trip. This car, however, was semi-autonomous by nature: it used neural networks to control the steering wheel, but throttle and brakes were human-controlled.

From 1996–2001, Alberto Broggi of the University of Parma launched the ARGO Project, which worked on enabling a modified Lancia Thema to follow the normal (painted) lane marks in an unmodified highway. The culmination of the project was a journey of 2,000 km over six days on the motorways of northern Italy dubbed MilleMiglia in Automatico, with an average speed of 90 km/h. 94% of the time the car was in fully automatic mode, with the longest automatic stretch being 54 km. The vehicle had only two black-and-white low-cost video cameras on board, and used stereoscopic vision algorithms to understand its environment, as opposed to the "laser, radar - whatever you need" approach taken by other efforts in the field.

Three US Government funded military efforts known as Demo I (US Army), Demo II (DARPA), and Demo III (US Army), are currently underway. Demo III (2001) demonstrated the ability of unmanned ground vehicles to navigate miles of difficult off-road terrain, avoiding obstacles such as rocks and trees. James Albus at NIST provided the Real-Time Control System which is a hierarchical control system. Not only were individual vehicles controlled (e.g. throttle, steering, and brake), but groups of vehicles had their movements automatically coordinated in response to high level goals.
In 2002, the DARPA Grand Challenge competitions were announced. The 2004 and 2005 DARPA competitions allowed international teams to compete in fully autonomous vehicle races over rough unpaved terrain and in a non-populated suburban setting. The 2007 DARPA challenge, the DARPA urban challenge, involved autonomous cars driving in an urban setting.

In 2008, General Motors stated that they will begin testing driverless cars by 2015, and they could be on the road by 2018.

In 2010 VisLab ran VIAC, the VisLab Intercontinental Autonomous Challenge, a 13,000 km test run of autonomous vehicles. The four driverless electric vans successfully ended the drive from Italy to China via the arriving at the Shanghai Expo on 28 October.
CHAPTER 3
RECENT PROJECTS

The work done so far varies significantly in its ambition and its demands in terms of modification of the infrastructure. Broadly, there are three approaches:

Fully autonomous vehicle

Various enhancements to the infrastructure (either an entire area, or specific lanes) to create a self-driving closed system.

"assistance" systems that incrementally remove requirements from the human driver (e.g. improvements to cruise control)

An important concept that cuts across several of the efforts is vehicle platoons. In order to better utilize road-space, vehicles are assembled into ad-hoc train-like "platoons", where the driver (either human or automatic) of the first vehicle makes all decisions for the entire platoon. All other vehicles simply follow the lead of the first vehicle.

3.1 FULLY AUTONOMOUS

Fully autonomous driving requires a car to drive itself to a pre-set target using unmodified infrastructure. The final goal of safe door-to-door transportation in arbitrary environments is not yet reached though.

Autonomous robots are robots that can perform desired tasks in unstructured environments without continuous human guidance. Many kinds of robots have some degree of autonomy. Different robots can be autonomous in different ways. A high degree of autonomy is particularly desirable in fields such as space exploration, cleaning floors, mowing lawns, and waste water treatment.

Some modern factory robots are "autonomous" within the strict confines of their direct environment. It may not be that every degree of freedom exists in their surrounding environment, but the factory robot's workplace is challenging and can often contain chaotic, unpredicted
variables. The exact orientation and position of the next object of work and (in the more advanced factories) even the type of object and the required task must be determined. This can vary unpredictably (at least from the robot's point of view).

One important area of robotics research is to enable the robot to cope with its environment whether this be on land, underwater, in the air, underground, or in space.

A fully autonomous robot has the ability to

- Gain information about the environment.
- Work for an extended period without human intervention.
- Move either all or part of itself throughout its operating environment without human assistance.
- Avoid situations that are harmful to people, property, or itself unless those are part of its design specifications.

An autonomous robot may also learn or gain new capabilities like adjusting strategies for accomplishing its task(s) or adapting to changing surroundings.

3.1.1 VEHICLES FOR SURFACED ROADS

- Google driverless car, with a test fleet of autonomous vehicles that by October 2010 have driven 140,000 miles (230,000 km) without any incidents.

- The 800 million Euro EUREKA Prometheus Project on autonomous vehicles (1987–1995). Among its culmination points were the twin robot vehicles VITA-2 and VaMP of Diamler-Benz and Ernst Dickmanns, driving long distances in heavy traffic (see #History above).

- The VIAC Challenge, in which 4 vehicles drove from Italy to China on a 13,000 kilometers (8,100 mi) trip with only limited occasions intervene by human, such as in the Moscow traffic jams and when passing toll stations. This is the longest-ever trip by an unmanned vehicle.

- The third competition of the DARPA Grand Challenge held in November 2007. 53 teams qualified initially, but after a series of qualifying rounds, only eleven teams entered the final
race. Of these, six teams completed navigating through the non-populated urban environment, and the Carnegie Mellon University team won the $2 million prize.

- The ARGO vehicle (see #History above) is the predecessor of the BRAiVE vehicle, both from the University of Parma's Vis Lab. Argo was developed in 1996 and demonstrated to the world in 1998; BRAiVE was developed in 2008 and firstly demonstrated in 2009 at the IEEE IV conference in Xi’an, China.
- Stanford Racing Team's junior car is an autonomous driverless car for paved roads. It is intended for civilian use
- The Volkswagen Golf GTI 53+1 is a modified Volkswagen Golf GTI capable of autonomous driving. The Golf GTI 53+1 features a implemented system that can be integrated into any car. This system is based around the MicroAutoBox from dSpace. This, as it was intended to test VW hardware without a human driver (for consistent test results).
- The Audi TTS Pikes Peak is a modified Audi TTS, working entirely on GPS, and thus without additional sensors. The car was designed by Burkhard Huhnke of Volkswagen Research.
- Stadtpilot, Technical University Braunschweig.
- AutoNOMOS - part of the Artificial Intelligence Group of the Ferie Universitat Berlin.

3.1.2 FREE-RANGING VEHICLES

There are four clusters of activity relating to free-ranging off-road cars. Some of these projects are military-oriented.

- US military DARPA Grand Challenge

The US Department OF Defence announced on the July 30, 2002 a "Grand Challenge", for US-based teams to produce a vehicle that could autonomously navigate and reach a target in the desert of the south western USA.

In March 2004, the first competition was held, for a prize-money of $1 million. Not one of the 25 entrants completed the course. However, in the second competition held in October 2005 five different teams completed the 135-mile (217 km) course, and the Stanford University team won the $2 million prize.
November 3rd, 2007, the third competition was held and $3.5 million dollar in cash prizes, trophies and medals were awarded. Six driverless vehicles were able to complete the 55 miles (89 km) of urban traffic in the 2007 DARPA Urban Challenge rally style race. 1st Place - Tartan Racing, Pittsburgh, PA; 2nd Place - Stanford Racing Team, Stanford, CA; 3rd Place - Victor Tango, Blacksburg, VA.

- European Land-Robot Trial (ELROB)

    The German Department of Defence held an exhibition trade show (ELROB) for demonstrating automated vehicles in May 2006. The event included various military automated and remotely-operated robots, for various military uses. Some of the systems on display could be ordered and implemented immediately. In August 2007 a civilian version of the event was held in Switzerland.

    The Smart Team from Switzerland presented "a Vehicle for Autonomous Navigation and Mapping in Outdoor Environments". For pictures of their ELROB demo, see this.

- The Israeli Military-Industrial Complex

    As a followup from its success with Unmanned Combat Air Vehicles, and following the construction of the Israeli West Bank Barrier there has been significant interest in developing a fully automated border-patrol vehicle. Two projects, by Elbit Systems and Israel Aircraft Industries are both based on the locally-produced Armored "Tomcar" and have the specific purpose of patrolling barrier fences against intrusions.

    The "SciAutonics II" team in the 2004 DARPA Challenge used Elbit's version of the Tom car.

- Korean Autonomous Vehicle Competition (AVC) organized by Hyundai Kia Automotive Group

    In November 2010, the first competition was held, for a winning prize-money of $100 thousand, and the Hanyang University A1 team won the $100 thousand prize.
3.2 PRE-BUILT INFRASTRUCTURE

The following projects were conceived as practical attempts to use available technology in an incremental manner to solve specific problems, like transport within a defined campus area, or driving along a stretch of motorway. The technologies are proven, and the main barrier to widespread implementation is the cost of deploying the infrastructure. Such systems already function in many airports, on railroads, and in some European towns.

3.2.1 DUAL MODE TRANSIT-MONORAIL

There is a family of projects, all currently still at the experimental stage, that would combine the flexibility of a private automobile with the benefits of a monorail system. The idea is that privately-owned cars would be built with the ability to dock themselves onto a public monorail system, where they become part of a centrally managed, fully computerized transport system—more akin to a driverless train system (as already found in airports) than to a driverless car. This idea is also known a Dual mode transit. (See also Personal rapid transit for another concept along those lines, for purely public transport.)

Groups working on this concept are:

- RUF (Denmark)
- BiWay (UK)
- ATN (New Zealand)
- Tri Track (Texas, United States)

MONORAIL:

The KL Monorail in Kuala Lumpur Malaysia, a straddle-beam monorail
A **monorail** is a rail-based transportation system based on a single rail, which acts as its sole support and its guideway. The term is also used variously to describe the beam of the system, or the vehicles traveling on such a beam or track. The term originates from the contraction of the words *mono* (one) and *rail*, from as early as 1897, possibly from German engineer Eugen Langen who called an elevated railway system with wagons suspended the *Eugen Langen One-railed Suspension Tramway* (Einschienige Hängebahn System Eugen Langen). The transportation system is often referred to as a railway. Colloquially, the term "monorail" is often used erroneously to describe any form of elevated rail or peoplemover. In fact, the term solely refers to the style of track, not its elevation.

**DUAL-MODE TRANSIT:**

- JR Hokkaido DMV tested.

**Dual mode transit** describes transportation systems in which vehicles operate on both public roads and on a guideway; thus using two modes of transport.

In a typical dual mode transit system, private vehicles comparable to automobiles would be able to travel under driver control on the street, but then enter a guideway, which may be a specialized form of Railway or monorail, for automated travel for an extended distance.

Examples of this concept include the TriTrack, RUF Megarail and JR Hokkaido. Dual-mode transit seeks to address a similar audience as personal rapid transit.

### 3.2.2 AUTOMATED HIGHWAY SYSTEMS

Automated highway systems (**AHS**) are an effort to construct special lanes on existing highways that would be equipped with magnets or other infrastructure to allow vehicles to stay in the center of the lane, while communicating with other vehicles (and with a central system) to avoid collision and manage traffic. Like the dual-mode monorail, the idea is that cars remain private and independent, and just use the AHS system as a quick way to move along designated routes. AHS allows specially equipped cars to join the system using special 'acceleration lanes' and to leave through 'deceleration lanes'. When leaving the system each car verifies that its driver is
ready to take control of the vehicle, and if that is not the case, the system parks the car safely in a predesignated area.

Some implementations use radar to avoid collisions and coordinate speed.

One example that uses this implementation is the AHS demo of 1997 near San Diego, sponsored by the US government, in coordination with the State of California and Carnegie Mellon University. The test site is a 12-kilometer, high-occupancy-vehicle (HOV) segment of Interstate 15, 16 kilometers north of downtown San Diego. The event generated much press coverage.

This concerted effort by the US government seems to have been pretty much abandoned because of social and political forces, above all else the desire to create a less futuristic and more marketable solution.

As of 2007, a three-year project is underway to allow robot controlled vehicles, including buses and trucks, to use a special lane along 20 Interstate 805. The intention is to allow the vehicles to travel at shorter following distances and thereby allow more vehicles to use the lanes. The vehicles will still have drivers since they need to enter and exit the special lanes. The system is being designed by Swoop Technology, based in San Diego County.

**PLATOON (automobile):**

Grouping vehicles into platoons is a method of increasing the capacity of roads. An automated highway system is a proposed technology for doing this.

Platoons decrease the distances between cars using electronic, and possibly mechanical, coupling. This capability would allow many cars to accelerate or brake simultaneously. Instead of waiting after a traffic light changes to green for drivers ahead to react, a synchronized platoon would move as one, allowing up to a fivefold increase in traffic throughput if spacing is diminished that much. This system also allows for a closer headway between vehicles by eliminating reacting distance needed for human reaction.
Platoon capability might require buying new cars, or it may be something that can be retrofitted. Drivers would probably need a special license endorsement on account of the new skills required and the added responsibility when driving in the lead.

Smart cars with artificial intelligence could automatically join and leave platoons. The automated highway system is a proposal for one such system, where cars organise themselves into platoons of eight to twenty-five.

### 3.2.3 FREE-RANGING ON GRID

Frog Navigation Systems (the Netherlands) applies the FROG (free-ranging on grid) technology. The technology consists of a combination of autonomous vehicles and a supervisory central system. The company's purpose-built electric vehicles locate themselves using odometry readings, recalibrating themselves occasionally using a "maze" of magnets embedded in the environment, and GPS. The cars avoid collisions with obstacles located in the environment using laser (long range) and ultra-sonic (short-range) sensors.

The vehicles are completely autonomous and plan their own routes from A to B. The supervisory system merely administers the operations and directs traffic where required. The system has been applied both indoors and outdoors, and in environments where 100+ automated vehicles are operational (container port). At this time the system is not suited yet for running the sheer number of vehicles encountered in urban settings. The company also has no intention of developing such technology at this time.

The FROG system is deployed for industrial purposes in factory sites, and is marketed as a pilot public transport system in the city of Capelle aan den IJssel by its subsidiary 2getthere. This system experienced an accident that proved to be caused by a Human error.

### 3.3 DRIVER-ASSISTANCE
Though these products and projects do not aim explicitly to create a fully autonomous car, they are seen as incremental stepping-stones in that direction. Many of the technologies detailed below will probably serve as components of any future driverless car — meanwhile they are being marketed as gadgets that assist human drivers in one way or another. This approach is slowly trickling into standard cars (e.g. improvements to cruise control).

Driver-assistance mechanisms are of several distinct types, sensorial-informative, actuation-corrective, and systemic.

### 3.3.1 SENSORIAL-INFORMATIVE

These systems warn or inform the driver about events that may have passed unnoticed, such as

- Lane Departure Warning System (LDWS), for example from Iteris or MobileEye N.V.
- Rear-view alarm, to detect obstacles behind.
- Visibility aids for the driver, to cover blind spots and enhanced vision systems such as radar, wireless vehicle safety communications and night vision.
- Infrastructure-based, driver warning/information-giving systems, such as those developed by the Japanese government

### LANE DEPARTURE WARNING SYSTEM:

Roadway with lane markings

In road-transport terminology, a **lane departure warning system** is a mechanism designed to warn a driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems are designed to minimize accidents by addressing the main causes of collisions: driving error, distraction and drowsiness. In 2009 the NHTSA began studying whether to mandate lane departure warning systems and frontal collision warning systems on automobiles.

There are two main types of systems:
- Systems which warn the driver (lane departure warning, LDW) if the vehicle is leaving its lane. (visual, audible, and/or vibration warnings)
- Systems which warn the driver and if no action is taken automatically take steps to ensure the vehicle stays in its lane (lane keeping system, LKS).

The first production lane departure warning system in Europe was developed by the United States's Iteris Company for Mercedes Actros commercial trucks. The system debuted in 2000 and is now available on most trucks sold in Europe.

In 2002, the Iteris system became available on Freightliner Trucks' trucks in North America. In all of these systems, the driver is warned of unintentional lane departures by an audible rumble strip sound generated on the side of the vehicle drifting out of the lane. No warnings are generated if, before crossing the lane, an active turn signal is given by the driver.

**Sensor types**

Lane warning/keeping systems are based on:

- video sensors in visual domain (mounted behind the windshield, typically integrated beside the rear mirror)
- laser sensors mounted in the vehicle front
- infrared sensors (mounted either behind the windshield or under the vehicle)
- Audi began in 2007 offering its Audi Lane Assist feature.

**BLIND SPOT (VEHICLE):**

A **blind spot** in a vehicle are areas around the vehicle that cannot be directly observed under existing circumstances. Blind spots exist in a wide range of vehicles: cars, trucks, motorboats and aircraft.

The blue car's driver sees the green car through his mirrors but cannot see the red car without turning to check his **blind spot**.
As one is driving an automobile, blind spots are the areas of the road that cannot be seen while looking forward or through either the rear-view or side mirrors. The most common are the rear quarter blind spots, areas towards the rear of the vehicle on both sides. Vehicles in the adjacent lanes of the road that fall into these blind spots may not be visible using only the car's mirrors. Rear quarter blind spots can be:

- checked by turning one's head briefly (risking rear-end collisions),
- eliminated by reducing overlap between side and rear-view mirrors, or
- Reduced by installing mirrors with larger fields-of-view.

Other areas that are sometimes called blind spots are those that are too low to see behind, in front, or to the sides of a vehicle, especially those with a high seating position, such as vans, trucks, and SUVs. Detection of vehicles or other objects in such blind spots are aided by systems such as video cameras or distance sensors, though these remain uncommon or expensive options in general-purpose automobiles.

**RADAR:**

**Radar** is an object-detection system which uses electromagnetic waves — specifically radio waves — to determine the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. The radar dish, or antenna, transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter.

A long-range radar antenna, known as ALTAIR, used to detect and track space objects in conjunction with ABM testing at the Ronald Reagan Test Site on Kwajalein Atoll.

A radar system has a transmitter that emits radio waves called radar signals in predetermined directions. When these come into contact with an object they are usually reflected and/or scattered in many directions. Radar signals are reflected especially well by materials of considerable electrical conductivity—especially by most metals, by seawater, by wet land, and by wetlands. Some of these make the use of radar altimeters possible. The radar signals that are
reflected back towards the transmitter are the desirable ones that make radar work. If the object is moving either closer or farther away, there is a slight change in the frequency of the radio waves, due to the Doppler Effect.

**WIRELESS VEHICLE SAFETY COMMUNICATION:**

Wireless vehicle safety communications telematics aid in car safety and road safety. It is an electronic sub-system in a car or other vehicle for the purpose of exchanging safety information, about such things as road hazards and the locations and speeds of vehicles, over short range radio links. This may involve temporary ad hoc wireless local area networks.

Wireless units will be installed in vehicles and probably also in fixed locations such as near traffic signals and emergency call boxes along the road. Sensors in the cars and at the fixed locations, as well as possible connections to wider networks, will provide the information, which will be displayed to the drivers in some way. The range of the radio links can be extended by forwarding messages along multi-hop paths. Even without fixed units, information about fixed hazards can be maintained by moving vehicles by passing it backwards. It also seems possible for traffic lights, which one can expect to become smarter, to use this information to reduce the chance of collisions.

Further in the future, it may connect directly to the adaptive cruise control or other vehicle control aids. Cars and trucks with the wireless system connected to their brakes may move in convoys, to save fuel and space on the roads. When any column member slows down, all those behind it will automatically slow also. There are also possibilities that need less engineering effort.

**NIGHT VISION**

Night vision is the ability to see in a dark environment. Whether by biological or technological means, night vision is made possible by a combination of two approaches: sufficient spectral range, and sufficient intensity range. Humans have poor night vision compared to many animals, in part because the human eye lacks a tapetum lucidum.

**TYPES OF RANGES:**
**SPECTRAL RANGE:**

Night-useful spectral range techniques can sense radiation that is invisible to a human observer. Human vision is confined to a small portion of the electromagnetic spectrum called visible light. Enhanced spectral range allows the viewer to take advantage of non-visible sources of electromagnetic radiation (such as near-infrared or ultraviolet radiation). Some animals can see using much more of the infrared and/or ultraviolet spectrum than humans.

**INTENSITY RANGE:**

Sufficient intensity range is simply the ability to see with very small quantities of light. Although the human visual system can, in theory, detect single photons under ideal conditions, the neurological noise filters limit sensitivity to a few tens of photons, even in ideal conditions. Enhanced intensity range is achieved via technological means through the use of an image intensifier, gain multiplication CCD, or other very low-noise and high-sensitivity array of photodetectors.

**MOTION DETECTOR:**

A motion detector is a device that contains a physical mechanism or electronic sensor that quantifies motion that can be either integrated with or connected to other devices that alert the user of the presence of a moving object within the field of view. They form a vital component of comprehensive security systems, for both homes and businesses.

An electronic motion detector contains a motion sensor that transforms the detection of motion into an electric signal. This can be achieved by measuring optical or acoustical changes in the field of view. Most motion detectors can detect up to 15–25 meters (50–80 feet).

There are basically three types of sensors used in motion detectors spectrum:

- Passive infrared sensor (PIR)
  
  Looks for body heat. No energy is emitted from the sensor.

- Ultrasonic (active)
**Sends out pulses and measures the reflection off a moving object.**

Microwave (active)

Sensor sends out microwave pulses and measures the reflection off a moving object. Similar to a police radar gun.

**ELECTRONIC STABILITY CONTROL:**

**Electronic Stability Control (ESC)** is a computerized technology that improves safety through a vehicle's stability by detecting and minimizing skids. When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to individual wheel, such as the outer front wheel to counter oversteer or the inner rear wheel to counter understeer. Some ESC systems also reduce engine power until control is regained. ESC does not improve a vehicle's cornering performance; instead, it helps to minimize the loss of control. According to IIHS and NHTSA, one-third of fatal accidents could have been prevented by the technology.

During normal driving, ESC works in the background and continuously monitors steering and vehicle direction. It compares the driver's intended direction (determined through the measured steering wheel angle) to the vehicle's actual direction (determined through measured lateral acceleration, vehicle rotation (yaw), and individual road wheel speeds).

ESC intervenes only when it detects loss of steering control, i.e. when the vehicle is not going where the driver is steering. This may happen, for example, when skidding during emergency evasive swerves, understeer or oversteer during poorly judged turns on slippery roads, or hydroplaning. ESC estimates the direction of the skid, and then applies the brakes to individual wheels asymmetrically in order to create torque about the vehicle's vertical axis, opposing the skid and bringing the vehicle back in line with the driver's commanded direction. Additionally, the system may reduce engine power or operate the transmission to slow the vehicle down.

**3.2.2 ACTUATION-CORRECTIVE:**

These systems modify the driver's instructions so as to execute them in a more effective way, for example the most widely deployed system of this type is ABS; conversely power steering is not a control mechanism, but just a convenience - it is not involved in decision making.
• Anti-lock braking system (ABS) (also Emergency Braking Assistance (EBD), often coupled with Electronic brake force distribution (EBD), which prevents the brakes from locking and losing traction while braking. This shortens stopping distances in most cases and, more importantly, allows the driver to steer the vehicle while braking.

• Traction control system (TCS) actuates brakes or reduces throttle to restore traction if driven wheels begin to spin.

• Four wheel drive (AWD) with a centre differential. Distributing power to all four wheels lessens the chances of wheel spin. It also suffers less from oversteer and understeer.

• Electronic stability control (ESC) (also known for Mercedes-Benz proprietary Electronic Stability Program (ESP), Acceleration Slip Regulation (ASR) and Electronic differential lock (EDL)). Uses various sensors to intervene when the car senses a possible loss of control. The car's control unit can reduce power from the engine and even apply the brakes on individual wheels to prevent the car from understeering or oversteering.

• Dynamic steering response (DSR) corrects the rate of power steering system to adapt it to vehicle's speed and road conditions.

ANTI-LOCK BRAKING SYSTEM (ABS):

An anti-lock braking system (ABS) is a safety system that allows the wheels on a motor vehicle to continue interacting tractively with the road surface as directed by driver steering inputs while braking, preventing the wheels from locking up (that is, ceasing rotation) and therefore avoiding skidding.

An ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on loose surfaces like gravel or snow-covered pavement, an ABS can significantly increase braking distance, although still improving vehicle control.

Since initial widespread use in production cars, anti-lock braking systems have evolved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities and implementation, is known as electronic brakeforce distribution (EBD), traction control system, emergency brake assist, or electronic stability control (ESC).
HISTORY:

EARLY SYSTEMS:

The ABS was first developed for aircraft use in 1929 by the French automobile and aircraft pioneer, Gabriel Voisin, as threshold braking on airplanes is nearly impossible. An early system was Dunlop's Maxaret system, which was introduced in the 1950s and is still in use on some aircraft models. These systems use a flywheel and valve attached to a hydraulic line that feeds the brake cylinders. The flywheel is attached to a drum that runs at the same speed as the wheel. In normal braking, the drum and flywheel should spin at the same speed.

MODERN SYSTEMS:

Chrysler, together with the Bendix Corporation, introduced a computerized, three-channel, four-sensor all-wheel ABS called "Sure Brake" for its 1971 Imperial. It was available for several years thereafter, functioned as intended, and proved reliable. In 1971, General Motors introduced the "Trackmaster" rear-wheel only ABS as an option on their Rear-wheel drive Cadillac models. In the same year, Nissan offered an EAL (Electro Anti-lock System) as an option on the Nissan President, which became Japan's first electronic ABS.

In 1988, BMW introduced the first motorcycle with an electronic-hydraulic ABS: the BMW K100. Honda followed suit in 1992 with the launch of its first motorcycle ABS on the ST1100 Pan European.

OPERATION:

The anti-lock brake controller is also known as the CAB (Controller Anti-lock Brake).

A typical ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics. The ECU constantly monitors the rotational speed of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than
the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via brake pedal pulsation. Some anti-lock system can apply or release braking pressure 16 times per second.

The ECU is programmed to disregard differences in wheel rotative speed below a critical threshold, because when the car is turning, the two wheels towards the center of the curve turn slower than the outer two. For this same reason, a differential is used in virtually all roadgoing vehicles.

If a fault develops in any part of the ABS, a warning light will usually be illuminated on the vehicle instrument panel, and the ABS will be disabled until the fault is rectified.

The modern ABS applies individual brake pressure to all four wheels through a control system of hub-mounted sensors and a dedicated micro-controller. ABS is offered or comes standard on most road vehicles produced today and is the foundation for ESC systems, which are rapidly increasing in popularity due to the vast reduction in price of vehicle electronics over the years.

Modern electronic stability control (ESC or ESP) systems are an evolution of the ABS concept. Here, a minimum of two additional sensors are added to help the system work: these are a steering wheel angle sensor, and a gyroscopic sensor. The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the ESC software will brake the necessary individual wheel(s) (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends.

The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much.

The ABS equipment may also be used to implement a traction control system (TCS) or Anti-Slip Regulation (ASR) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. Manufacturers often offer this as a separately priced option even though the infrastructure is
largely shared with ABS. More sophisticated versions of this can also control throttle levels and
brakes simultaneously.

**ELECTRONIC BRAKEFORCE DISTRIBUTION:**

Electronic brakeforce distribution (EBD or EBFD), Electronic brakeforce limitation (EBL) or Electronic brake assist (EBA) is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle's brakes, based on road conditions, speed, loading, etc. Always coupled with anti-lock braking systems, EBD can apply more or less braking pressure to each wheel in order to maximize stopping power whilst maintaining vehicular control. Typically, the front end carries the most weight and EBD distributes less braking pressure to the rear brakes so the rear brakes do not lock up and cause a skid. In some systems, EBD distributes more braking pressure at the rear brakes during initial brake application before the effects of weight transfer become apparent.

**OPERATION:**

The job of the EBD as a subsystem of the ABS system is to control the effective adhesion utilization by the rear wheels. The pressure of the rear wheels is approximated to the ideal brake force distribution in a partial braking operation. To do so, the conventional brake design is modified in the direction of rear axle overbraking, and the components of the ABS are used. EBD reduces the strain on the hydraulic brake force proportioning valve in the vehicle. EBD optimizes the brake design with regard to: adhesion utilization; driving stability; wear; temperature stress; and pedal force.

EBD may work in conjunction with ABS and Electronic Stability Control ("ESC") to minimize yaw accelerations during turns. ESC compares the steering wheel angle to vehicle turning rate using a yaw rate sensor. "Yaw" is the vehicle's rotation around its vertical center of gravity (turning left or right). If the yaw sensor detects more/less yaw than the steering wheel angle should create, the car is understeering or oversteering and ESC activates one of the front or rear brakes to rotate the car back onto its intended course. For example, if a car is making a left turn and begins to understeer (the car plows forward to the outside of the turn) ESC activates the left rear brake, which will help turn the car left. The sensors are so sensitive, and the actuation is so
quick that the system may correct direction before the driver reacts. ABS helps prevent wheel lock-up and EBD helps apply appropriate brake force to make ESC work effectively.

**TRACTION CONTROL SYSTEM:**

Traction control system (TCS) actuates brakes or reduces throttle to restore traction if driven wheels begin to spin. A *traction control system (TCS)*, also known as *Anti-Slip Regulation (ASR)*, is typically (but not necessarily) a secondary function of the anti-lock braking system on production vehicles, and is designed to prevent loss of traction of the driven road wheels, and therefore maintain the control of the vehicle when excessive throttle is applied by the driver and the condition of the road surface (due to varying factors) is unable to cope with the torque applied.

The intervention can consist of one or more of the following:

- Reduces or suppress the spark to one or more cylinders
- Reduce fuel supply to one or more cylinders
- Brake one or more wheels
- Close the throttle, if the vehicle is fitted with drive by wire throttle
- In turbo-charged vehicles, the boost control solenoid can be actuated to reduce boost and therefore engine power.

Typically, the traction control system shares the electro-hydraulic brake actuator (but does not use the conventional master cylinder and servo), and the wheel speed sensors with the anti-lock braking system.

**OPERATION:**

When the traction control computer (often incorporated into another control unit, like the anti-lock braking system module) detects one or more drive wheels spinning significantly faster than
another, it will use the ABS to apply brake friction to the wheels that are spinning too fast. This braking action on the slipping wheel(s) will cause power to be transferred to the wheels that are not due to the mechanical action within a differential. all-wheel drive vehicles also often have an electronically controlled coupling system in the transfer case or transaxle that is engaged (in an active part time AWD), or locked up tighter (in a true full-time set up that drives all the wheels with some power all the time) to supply the non-slipping wheels with (more) torque.

This often occurs in conjunction with the powertrain computer reducing available engine torque by electronically limiting throttle application and/or fuel delivery, retarding ignition spark, completely shutting down engine cylinders, and a number of other methods, depending on the vehicle and how much technology is used to control the engine and transmission.

**USE OF TRACTION CONTROL:**

- **In road cars:** Traction control has traditionally been a safety feature in high-performance cars, which would otherwise need very sensitive throttle input to keep them from spinning the driven wheels when accelerating, especially in wet, icy or snowy conditions. In recent years, traction control systems have become widely available in non-performance cars, minivans, and light trucks.

- **In race cars:** Traction control is used as a performance enhancement, allowing maximum traction under acceleration without wheel spin. When accelerating out of turn, it keeps the tires at the optimum slip ratio

- **In motor cycles:** Traction control for a production motorcycle was first available with the Honda ST1100 in 1992. By 2009, traction control was an option for several models offered by BMW and DUCATI, and the model year 2010 kawasaki (1400GTR).

- **In off roads vehicles:** Traction control is used instead or in addition to the mechanical limited slip or locking differential. It is often implemented with, as well as other computerized controls of the engine and transmission. The spinning wheel is slowed down with short applications of brakes, diverting more torque to the non-spinning wheel.

**TRACTION CONTROL IN CORNERING:**
Traction control is not just used for improving acceleration under slippery conditions. It can also help a driver to corner more safely. If too much throttle is applied during cornering, the drive wheels will lose traction and slide sideways. This occurs as understeer in front wheel drive vehicles and oversteer in rear wheel drive vehicles. Traction control can prevent this from happening by limiting power to the wheels. It cannot increase the limits of grip available and is used only to decrease the effect of driver error or compensate for a driver's inability to react quickly enough to wheel slip.

Automobile manufacturers state in vehicle manuals that traction control systems should not encourage dangerous driving or encourage driving in conditions beyond the drivers' control.

**FOUR WHEEL DRIVE:**

Four wheel drive (AWD) with a centre differential. Distributing power to all four wheels lessens the chances of wheel spin. It also suffers less from oversteer and understeer.

**Four-wheel drive, 4WD, or 4×4** ("four by four") is a four-wheeled vehicle with a drivetrain that allows all four wheels to receive torque from the engine simultaneously. While many people associate the term with off-road vehicles and Sport utility vehicles, powering all four wheels provides better control than normal road cars on many surfaces, and is an important part in the sport of rallying.

In abbreviations such as 4×4, the first figure is normally taken as the total number of wheels and the second is normally taken as the number of powered wheels (the numbers are actually axle-ends to allow for more than one wheel on each end of an axle). 4×2 means a four-wheel vehicle in which engine power is transmitted to only two axle-ends: the front two in front-wheel drive or the rear two in rear-wheel drive.

**4WD VS ALL WHEEL DRIVE:**
The term *four-wheel drive* typically describes truck-like vehicles that may allow the driver to manually switch (sometimes with an automatic option) between two-wheel drive mode (if available) for streets and four-wheel drive mode for low-traction conditions such as ice, mud, snow, or loose gravel.

*All-wheel drive* (AWD) is often used to describe a "full time" 4WD that may be used on dry pavement without damaging the differentials, although the term may be abused when marketing a vehicle. AWD can be used on dry pavement because it employs a center differential, which allows each axle to rotate at a different speed. This eliminates driveline binding, wheel hop, and other driveline issues associated with the use of 4WD on dry pavement.

**4WD VS INDIVIDUAL WHEEL DRIVE:**

The term *Individual-wheel drive* is coined to identify those electric vehicles whereby each wheel is driven by its own individual electric motor. This system essentially has inherent characteristics in it that would be generally contributed to Four-Wheel drive systems like the distribution of the available power to the wheels. The IWD drive is not limited to 4 wheels as there is generally a motor that drives each wheel that can number upwards of 4, but could also identify a single wheeled vehicle.

**ELECTRONIC STABILITY CONTROL:**

Electronic Stability Control (ESC) (also known for Mercedes-Benz proprietary Electronic Stability Program (ESP), Acceleration Slip Regulation (ASR) and Electronic differential lock (EDL)). Uses various sensors to intervene when the car senses a possible loss of control. The car's control unit can reduce power from the engine and even apply the brakes on individual wheels to prevent the car from understeering or oversteering.

**Electronic Stability Control (ESC)** is a computerized technology that improves safety through a vehicle's stability by detecting and minimizing skids. When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to individual wheel, such as the outer front wheel to counter
oversteer or the inner rear wheel to counter understeer. Some ESC systems also reduce engine power until control is regained. ESC does not improve a vehicle's cornering performance; instead, it helps to minimize the loss of control. According to IIHS and NHTSA, one-third of fatal accidents could have been prevented by the technology.

**OPERATION:**

During normal driving, ESC works in the background and continuously monitors steering and vehicle direction. It compares the driver's intended direction (determined through the measured steering wheel angle) to the vehicle's actual direction (determined through measured lateral acceleration, vehicle rotation (yaw), and individual road wheel speeds).

ESC intervenes only when it detects loss of steering control, i.e. when the vehicle is not going where the driver is steering. This may happen, for example, when skidding during emergency evasive swerves, understeer or oversteer during poorly judged turns on slippery roads, or hydroplaning. ESC estimates the direction of the skid, and then applies the brakes to individual wheels asymmetrically in order to create torque about the vehicle's vertical axis, opposing the skid and bringing the vehicle back in line with the driver's commanded direction. Additionally, the system may reduce engine power or operate the transmission to slow the vehicle down.

ESC can work on any surface, from dry pavement to frozen lakes. It reacts to and corrects skidding much faster and more effectively than the typical human driver, often before the driver is even aware of any imminent loss of control. In fact, this led to some concern that ESC could allow drivers to become overconfident in their vehicle's handling and/or their own driving skills. For this reason, ESC systems typically inform the driver when they intervene, so that the driver knows that the vehicle's handling limits have been approached. Most activate a dashboard indicator light and/or alert tone; some intentionally allow the vehicle's corrected course to deviate very slightly from the driver-commanded direction, even if it is possible to more precisely match it.
Indeed, all ESC manufacturers emphasize that the system is not a performance enhancement nor a replacement for safe driving practices, but rather a safety technology to assist the driver in recovering from dangerous situations. ESC does not increase traction, so it does not enable faster cornering (although it can facilitate better-controlled cornering). More generally, ESC works within inherent limits of the vehicle's handling and available traction between the tires and road. A reckless maneuver can still exceed these limits, resulting in loss of control. For example, in a severe hydroplaning scenario, the wheels that ESC would use to correct a skid may not even initially be in contact with the road, reducing its effectiveness.

In July 2004, on the Crown Majesta, Toyota offered a Vehicle Dynamics Integrated Management (VDIM) system that incorporated formerly independent systems, including ESC. This worked not only after the skid was detected but also to prevent the skid from occurring in the first place. Using electric variable gear ratio steering power steering this more advanced system could also alter steering gear ratios and steering torque levels to assist the driver in evasive maneuvers.

**COMPONENTS AND DESIGN:**

ESC incorporates yaw rate control into the anti-lock braking system (ABS). Yaw is a rotation around the vertical axis; i.e. spinning left or right. Anti-lock brakes enable ESC to brake individual wheels. Many ESC systems also incorporate a traction control system (TCS or ASR), which senses drive-wheel slip under acceleration and individually brakes the slipping wheel or wheels and/or reduces excess engine power until control is regained. However, ESC achieves a different purpose than ABS or Traction Control.

The ESC system uses several sensors to determine what the driver wants (input). Other sensors indicate the actual state of the vehicle (response). The control algorithm compares driver input to vehicle response and decides, when necessary, to apply brakes and/or reduce throttle by the amounts calculated through the state space (set of equations used to model the dynamics of the vehicle). The ESC controller can also receive data from an issue commands to other controllers on the vehicle such as an all wheel drive system or an active suspension system to improve vehicle stability and controllability.
The sensors used for ESC have to send data at all times in order to detect possible defects as soon as possible. They have to be resistant to possible forms of interference (rain, holes in the road, etc.). The most important sensors are:

- **Steering wheel angle sensor**: determines the driver's intended rotation; i.e. where the driver wants to steer. This kind of sensor is often based on AMR elements.
- **Yaw rate sensor**: measures the rotation rate of the car; i.e. how much the car is actually turning. The data from the yaw sensor is compared with the data from the steering wheel angle sensor to determine regulating action.
- **Lateral acceleration sensor**: often based on the Hall-effect. Measures the lateral acceleration of the vehicle.
- **Wheel speed sensor**: measures the wheel speed.

Other sensors can include:

- **Longitudinal acceleration sensor**: similar to the lateral acceleration sensor in design but can offer additional information about road pitch and also provide another source of vehicle acceleration and speed.
- **Roll rate sensor**: similar to the yaw rate sensor in design but improves the fidelity of the controller's vehicle model and correct for errors when estimating vehicle behavior from the other sensors alone.

ESC uses a hydraulic modulator to assure that each wheel receives the correct brake force. A similar modulator is used in ABS. ABS needs to reduce pressure during braking, only. ESC additionally needs to increase pressure in certain situations and an active vacuum brake booster unit may be utilized in addition to the hydraulic pump to meet these demanding pressure gradients.
The brain of the ESC system is the Electronic Control Unit (ECU). The various control techniques are embedded in it. Often, the same ECU is used for diverse systems at the same time (ABS, Traction control system climate control, etc.). The input signals are sent through the input-circuit to the digital controller. The desired vehicle state is determined based upon the steering wheel angle, its gradient and the wheel speed. Simultaneously, the yaw sensor measures the actual state. The controller computes the needed brake or acceleration force for each wheel and directs via the driver circuits the valves of the hydraulic modulator. Via a CAN interface the ECU is connected with other systems (ABS, etc.) in order to avoid giving contradictory commands.

Many ESC systems have an "off" override switch so the driver can disable ESC, which may be desirable when badly stuck in mud or snow, or driving on a beach, or if using a smaller-sized spare tire which would interfere with the sensors. Some systems also offer an additional mode with raised thresholds so that a driver can utilize the limits of adhesion with less electronic intervention. However, ESC defaults to "On" when the ignition is re-started. Some ESC systems that lack an "off switch", such as on many recent Toyota and Lexus vehicles, can be temporarily disabled through an undocumented series of brake pedal and handbrake operations. Furthermore, unplugging a wheel speed sensor is another method of disabling most ESC systems. The ESC implementation on newer Ford vehicles cannot be completely disabled even through the use of the "off switch". The ESC will automatically reactivate at highway speeds and below that if it detects a skid with the brake pedal depressed.

**ELECTRONIC DIFFERENTIAL LOCK:**

A **locking differential, diff-lock** or **locker** is a variation on the standard automotive differential. A locking differential may provide increased traction compared to a standard or "open" differential by restricting each of the two wheels on an axle to the same rotational speed without regard to available traction or differences in resistance seen at each wheel.

A locking differential is designed to overcome the chief limitation of a standard open differential by essentially "locking" both wheels on an axle together as if on a common shaft. This forces both wheels to turn in unison, regardless of the traction (or lack thereof) available to either wheel individually.
When the differential is unlocked (open differential), it allows each wheel to rotate at different speeds (such as when negotiating a turn), thus avoiding tire scuffing. An open (or unlocked) differential always provides the same torque (rotational force) to each of the two wheels, on that axle. So although the wheels can rotate at different speeds, they apply the same rotational force, even if one is entirely stationary, and the other spinning. (Equal torque, unequal rotational speed).

**TYPES**

**AUTOMATIC LOCKERS:**

Automatic lockers lock and unlock automatically with no direct input from the driver. Some automatic locking differential designs ensure that engine power is always transmitted to both wheels, regardless of traction conditions, and will "unlock" only when one wheel is required to spin faster than the other during cornering. They will never allow either wheel to spin slower than the differential carrier or axle as a whole. The most common example of this type would be the famous "Detroit Locker," also known as the "Detroit No-Spin," which replaces the entire differential carrier assembly. Others sometimes referred to as "lunchbox lockers," employ the stock differential carrier and replace only the internal spider gears and shafts with interlocking plates. An example of a "lunchbox locker" would be the Spartan Locker, manufactured by USA Standard Gear. Both types of automatic lockers will allow for a degree of differential wheel speed while turning corners in conditions of equal traction, but will otherwise lock both axle shafts together when traction conditions demand it.

- **Pros:** Automatic action, no driver interaction necessary, no stopping for (dis-) engagement necessary
- **Cons:** Intensified tire wear, noticeable impact on driving behaviour (most people often tend to understeer).

Some other automatic lockers operate as an "open", or unlocked differential until wheel spin is encountered and then they lockup. This style generally uses an internal governor to sense a difference in wheel speeds. An example of this would be GM's "Gov-Lok."
Some other automatic lockers operate as an "open," or unlocked differential until high torque is applied and then they lockup. This style generally uses internal gears systems with very high friction. An example of this would be ZF "sliding pins and cams" available for use in early VWs.

**SELECTIVE LOCKER:**

ARB Air locking differential fitted to a Mitsubishi Delica L400 LWB Diff

Selectable lockers allow the driver to lock and unlock the differential at will from the driver's seat. This can be accomplished many ways.

- Compressed air (pneumatics) like ARB's "Air Locker" or Yukon Gear & Axle's "Zip Locker".
- Cable operated mechanism as is employed on the "Ox Locker."
- Electronic solenoids and (electromagnetics) like Eaton's "ELocker." However, OEMs are beginning to offer electronic lockers as well. Nissan Corporations electric locker found as optional equipment on the Frontier (Navarra) & Xterra. 2011 Ford super duty F-250 and SRW F-350 4x4 models have a electronic locker as 390.00 USD option.
  - Pros: Allows the differential to perform as an "open" differential for improved driveability, maneuverability, provides full locking capability when it is desirable or needed
  - Cons: Mechanically complex with more parts to fail. Some lockers require vehicle to stop for engagement. Needs human interaction and forward-thinking regarding upcoming terrain. *Un-skilled* drivers often put massive stress on driveline components when leaving the differential in locked operation on terrain not requiring a locker.

**SPOOL:**

The internal spider gears of an open differential may also be welded together to create a locked axle; however, this method is not recommended as the welding process seriously compromises the metallurgical composition of the welded components, and can lead to failure of the unit under
stress. If it is desirable to have a spooled axle, the better option is to install either a mini-spool, which uses the stock carrier and replaces only the internal components of the differential, similar in installation to the lunchbox locker, or a full spool which replaces the entire carrier assembly with a single machined piece. A full spool is perhaps the strongest means of locking an axle, but has no ability to differentiate wheel speeds whatsoever, putting high stress on all affected driveline components.

UNDERSTEER:

*Understeer* and *oversteer* are vehicle dynamics terms used to describe the sensitivity of a vehicle to steering. Automotive engineers originally defined understeer and oversteer based on the gradient of the steering needed to make a turn in a steady-state condition (constant speed, constant radius) on a flat and level ground surface. Car and motorsport enthusiasts often use the terminology more generally in magazines and blogs to describe vehicle response to steering in all kinds of maneuvers, even on banked turns. Simply put, oversteer is what occurs when a car turns (steers) by more than (over) the amount commanded by the driver. Conversely, understeer is what occurs when a car steers under the amount commanded by the driver.

CONTRIBUTIONS TO UNDERSTEER:

Many properties of the vehicle affect the understeer gradient, including tire cornering stiffness, camber thrust, lateral force compliance steer, aligning torque, lateral load transfer, and compliance in the steering system. These individual contributions can be identified analytically or by measurement in a Bundorf analysis.

LIMIT CONDITIONS:

When an understeer vehicle is taken to frictional limits where it is no longer possible to increase lateral acceleration, the vehicle will follow a path with a radius larger than intended. Although the vehicle cannot increase lateral acceleration, it is dynamically stable.
When an oversteer vehicle is taken to frictional limits, it becomes dynamically unstable with a tendency to spin out. Although the vehicle is unstable in open-loop control, a skilled driver can maintain control a little past the point of instability with counter-steering. However, at some limit in lateral acceleration, it is not physically possible for even the most skilled driver to maintain a steady state and spinout will occur.

**OVERSTEER:**

Oversteer is a term for a car handling condition in which the slip angle of the rear tires is greater than the slip angle of the front tires. In other words, the amount that the car steers is over that commanded by the driver. The effect is opposite to that of understeer.

An oversteering car is referred to as "loose" or "free". Oversteer is a dynamically unstable condition; in other words, if control is lost, the vehicle will spin.

**CAUSES:**

The tendency of a car to oversteer is affected by several factors such as mechanical traction, aerodynamics and suspension, and driver control, and may be applicable at any level of lateral acceleration. Generally, oversteer is the condition when the slip angle of the rear tires exceeds that of the front tires, even when they are both small. Limit oversteer occurs when the rear tires reach the limits of their lateral traction during a cornering situation but the front tires have not, thus causing the rear of the vehicle to head towards the outside of the corner.

**YAW RATE:**

The terms oversteer and understeer are related to yaw rate and not to sideways movement. A car undergoes a circular spinning motion (yaw) as it turns, as well as sideways movement (towards the inside of the corner). Understeer and oversteer refer to the yaw motion. The difference between yaw and sideways movement is best demonstrated by practising turning an aircraft, because separate controls control each of the two movement types in aircraft. Consider a car with its steering wheel turned part way to one side and locked in that position. Now imagine that car rolling forward very slowly on a flat surface. It will move along an arc of a circle whose radius is
determined solely by the position of the wheels, since centrifugal force is minimal. Its sideways motion and yaw rate are hence interlinked and set by the steering wheel position.

CRITICAL SPEED:

Oversteering cars have an associated instability mode, which occurs at and above the critical speed. As this speed is approached, with the car on an approximately straight course, the steering becomes progressively more sensitive. At the critical speed the yaw velocity gain becomes infinite, that is, the car will turn violently in response to the slightest steering input or external disturbance. Above the critical speed analysis shows that the yaw response will be reversed for a given steering wheel input, such as a car turning left in response to turning the wheel to the right. This is an oversimplification, however, as the model used is linearised in many important ways. Understeering cars do not suffer from this, which is one of the reasons why high speed cars tend to be set up to understeer.

AERODYNAMIC STABILITY:

At first, aerodynamic oversteer was counteracted by setting the cars up with strong mechanical understeer, resulting in excessive understeer at lower speeds. Various means of achieving aerodynamic stability have since been developed, such as tail fins to move the centre of pressure back, the Kamm tail and the spoiler to reduce lift, rear wings to generate downward acting lift force, and air dams and skirts to reduce air pressure under the car, causing down force due to ground effect. Most of those features improve stability but increase drag, reducing top speed and increasing fuel consumption.

DYNAMIC STEERING RESPONSE (DSR):

Dynamic steering response (DSR) corrects the rate of power steering system to adapt it to vehicle's speed and road conditions.

Dynamic steering response (DSR) is a car safety technique that corrects the rate of hydraulic or electric power steering system to adapt it to vehicle's speed and road conditions. Similar to
DIRAVI, this system was first featured in the SEAT Leon Cupra R and has since been used in a wide range of models including the Ibiza, Cordoba, new Leon, Altea and new Toledo.

POWER STEERING:

The term power steering is usually used to describe a system that provides mechanical steering assistance to the driver of a land vehicle, for example, a car or truck. The power steering system in a vehicle is a type of servomechanism.

For many drivers, turning the steering wheel in a vehicle that doesn't have power steering requires more force (torque) than the driver finds comfortable, especially when the vehicle is moving at a very slow speed. Steering force is very sensitive to the weight of the vehicle, and nearly so much to its length, so this is most important for large vehicles. In a vehicle equipped with power steering, when the driver turns the steering wheel, he feels only a slight retarding force, so a vehicle equipped with power steering can be driven by any healthy driver, even when the vehicle is being parked. This is because the power steering system furnishes most of the energy required to turn the steered wheels of the car.

Most power steering systems in cars and light trucks today are hydraulic (that is, the force to turn the wheels is provided by a hydraulic piston, which is powered by high pressure hydraulic fluid), but in some cars and trucks, the steering force is provided by an electric motor.

ELECTRIC SYSTEMS:

Electric power steering (EPS or EPAS) is designed to use an electric motor to reduce effort by providing steering assist to the driver of a vehicle. Sensors detect the motion and torque of the steering column, and a computer module applies assistive torque via an electric motor coupled directly to either the steering gear or steering column. This allows varying amounts of assistance to be applied depending on driving conditions. The system allows engineers to tailor steering-gear response to variable-rate and variable-damping suspension systems achieving an ideal blend of ride, handling, and steering for each vehicle. On Fiat group cars the amount of assistance can be regulated using a button named "CITY" that switches between two different assist curves, while most other EPS systems have variable assist, which allows for more assistance as the speed of a vehicle decreases and less assistance from the system during high-speed situations. In the
event of component failure, a mechanical linkage such as a rack and pinion serves as a back-up in a manner similar to that of hydraulic systems.

Electric power steering should not be confused with drive-by-wire or steer-by-wire systems which use electric motors for steering, but without any mechanical linkage to the steering wheel.

Electric systems have a slight advantage in fuel efficiency because there is no belt-driven hydraulic pump constantly running, whether assistance is required or not, and this is a major reason for their introduction. Another major advantage is the elimination of a belt-driven engine accessory, and several high-pressure hydraulic hoses between the hydraulic pump, mounted on the engine, and the steering gear, mounted on the chassis. This greatly simplifies manufacturing and maintenance. By incorporating electronic stability control electric power steering systems can instantly vary torque assist levels to aid the driver in evasive manoeuvres.

The first electric power steering systems appeared on the Honda NSX in 1990, the FIAT Punto Mk2 in 1999, the Honda S2000 in 1999, and on the BMW Z4 in 2002. Today a number of manufacturers use electric power steering.

3.3.3 SYSTEMIC:

Automatic parking technology from Ford or Toyota selling for $700 take-up rate. The Lexus LS can park itself (parallel/reverse) via the ‘Advanced Parking Guidance system’—though only controlling the steering.

Follow another car on a motorway.

AUTOMATIC PARKING:

Automatic parking is an autonomous car maneuvering from a traffic lane into a parking place to perform parallel parking, perpendicular or angle parking. The automatic parking aims to enhance the comfort and safety of driving in constrained environments where much attention and experience is required to steer the car. The parking maneuver is achieved by means of
coordinated control of the steering angle and speed which takes into account the actual situation in the environment to ensure collision-free motion within the available space.

**ADVANCED PARKING GUIDANCE SYSTEM:**

**Intelligent Parking Assist System** (IPAS), also known as the **Advanced Parking Guidance System** (APGS) for Lexus models in the United States, is the first production automatic parking system developed by Toyota Motor Corporation in 2004 initially for the Japanese market hybrid Prius models and later Lexus models.

**TECHNOLOGY:**

The IPAS/AGPS uses computer processors which are tied to the vehicle's (sonar warning system) feature, backup camera, and two additional forward sensors on the front side fenders. The sonar park sensors, known as "Intuitive Parking Assist" or "Lexus Park Assist", includes multiple sensors on the forward and rear bumpers which detect obstacles, allowing the vehicle to sound warnings and calculate optimum steering angles during regular parking. These sensors plus the two additional parking sensors are tied to a central computer processor, which in turn is integrated with the backup camera system to provide the driver parking information.

When the sonar park sensors feature is used, the processor(s) calculate steering angle data which are displayed on the navigation/camera touchscreen along with obstacle information. The Intelligent Parking Assist System expands on this capability and is accessible when the vehicle is shifted to reverse (which automatically activates the backup camera). When in reverse, the backup camera screen features parking buttons which can be used to activate automated parking procedures. When the Intelligent Parking Assist System is activated, the central processor calculates the optimum parallel or reverse park steering angles and then interfaces with the Electric Power Steering systems of the vehicle to guide the car into the parking spot.
CHAPTER 4
EXISTING AND MISSING TECHNOLOGIES

In order to drive a car, a system would need to:

1. Understand its immediate environment (Sensors)
2. Know where it is and where it wants to go (Navigation)
3. Find its way in the traffic (motion planning)
4. Operate the mechanics of the vehicle (Actuation)

Arguably, 2½ of these problems are already solved: Navigation and Actuation completely, and Sensors partially, but improving fast. The main unsolved part is the motion planning.

4.1 SENSORS:

Sensors employed in driverless cars vary from the minimalist ARGO project's monochrome stereoscopy to Mobileye's inter-modal (video, infra-red, laser, radar) approach. The minimalist approach imitates the human situation most closely, while the multi-modal approach is "greedy" in the sense that it seeks to obtain as much information as is possible by current technology, even at the occasional cost of one car's detection system interfering with another's.

Mobileye N.V. is a technology company that focuses on the development of vision-based Advanced Driver Assistance Systems (ADAS) providing warnings for collision prevention and mitigation. Mobileye offers a wide range of driver safety solutions combining artificial vision image processing, multiple technological applications and information technology. Mobileye's vehicle detection systems, are currently only used for driver assistance, but are eminently suitable for a full-fledged driverless car. This video demonstrates the capabilities of the system: all pedestrians, cars, motorbikes etc. are clearly displayed in video, with a frame around them and the distance between "our" car and the object observed. The system also detects the objects' motion (direction and speed) and can so calculate relative speeds, and predict collisions.
4.2 NAVIGATION:

The ability to plot a route from where the vehicle is to where the user wants to be has been available for several years. These systems, based on the US military's Global Positioning System are now available as standard car fittings, and use satellite transmissions to ascertain the current location, and an on-board street database to derive a route to the target. The more sophisticated systems also receive radio updates on road blockages, and adapt accordingly. There are also sensors that greatly affect the whole nature of it.

GLOBAL POSITIONING SYSTEM:

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

Artist's conception of GPS Block II-F satellite in orbit

Civilian GPS receiver ("GPS navigation device") in a marine application.

GPS was created and realized by the U.S. Department of Defense (USDOD) and was originally run with 24 satellites. It was established in 1973 to overcome the limitations of previous navigation systems.

STRUCTURE:

The current GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (US). The U.S. Air Force develops, maintains, and operates the space and control segments. GPS satellites broadcast signals from space, and each GPS
receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time.

The space segment is composed of 24 to 32 satellites in medium Earth orbit and also includes the payload adapters to the boosters required to launch them into orbit. The control segment is composed of a master control station, an alternate master control station, and a host of dedicated and shared ground antennas and monitor stations. The user segment is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial, and scientific users of the Standard Positioning Service (see GPS navigation devices).

**SPACE SEGMENT:**

A visual example of the GPS constellation in motion with the Earth rotating. Notice how the number of satellites in view from a given point on the Earth's surface, in this example at 45°N, changes with time.

The space segment (SS) is composed of the orbiting GPS satellites or Space Vehicles (SV) in GPS parlance. The GPS design originally called for 24 SVs, eight each in three circular orbital planes,[35] but this was modified to six planes with four satellites each.[36] The orbital planes are centered on the Earth, not rotating with respect to the distant stars.[37] The six planes have approximately 55° inclination (tilt relative to Earth's equator) and are separated by 60° right ascension of the ascending node (angle along the equator from a reference point to the orbit's intersection).[38] The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on Earth's surface.[39] The result of this objective is that the four satellites are not evenly spaced (90 degrees) apart within each orbit. In general terms, the angular difference between satellites in each orbit is 30, 105, 120, and 105 degrees apart which, of course, sum to 360 degrees.
CONTROL SEGMENT:

The control segment is composed of

1. a master control station (MCS),
2. an alternate master control station,
3. four dedicated ground antennas and
4. six dedicated monitor stations

The MCS can also access U.S. Air Force Satellite Control Network (AFSCN) ground antennas (for additional command and control capability) and NGA (National Geospatial-Intelligence Agency) monitor stations. The flight paths of the satellites are tracked by dedicated U.S. Air Force monitoring stations in Hawaii, Kwajalein, Ascension Island, Diego Garcia, Colorado Springs, Colorado and Cape Canaveral, along with shared NGA monitor stations operated in England, Argentina, Ecuador, Bahrain, Australia and Washington DC. The tracking information is sent to the Air Force Space Command's MCS at Schriever Air Force Base 25 km (16 miles) ESE of Colorado Springs, which is operated by the 2nd Space Operations Squadron (2 SOPS) of the United States Air Force (USAF). Then 2 SOPS contacts each GPS satellite regularly with a navigational update using dedicated or shared (AFSCN) ground antennas (GPS dedicated ground antennas are located at Kwajalein, Ascension Island, Diego Garcia, and Cape Canaveral). These updates synchronize the atomic clocks on board the satellites to within a few nanoseconds of each other, and adjust the ephemeris of each satellite's internal orbital model. The updates are created by a Kalman filter that uses inputs from the ground monitoring stations, space weather information, and various other inputs.

Ground monitor station used from 1984 to 2007, on display at the Air Force Space & Missile Museum

Satellite maneuvers are not precise by GPS standards. So to change the orbit of a satellite, the satellite must be marked unhealthy, so receivers will not use it in their calculation. Then the maneuver can be carried out, and the resulting orbit tracked from the ground. Then the new ephemeris is uploaded and the satellite marked healthy again.
USER SEGMENT:

The user segment is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial and scientific users of the Standard Positioning Service. In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). They may also include a display for providing location and speed information to the user. A receiver is often described by its number of channels: this signifies how many satellites it can monitor simultaneously. Originally limited to four or five, this has progressively increased over the years so that, as of 2007[update], receivers typically have between 12 and 20 channels.

AUTOMOTIVE NAVIGATION SYSTEM:

An automotive navigation system is a satellite navigation system designed for use in automobiles. It typically uses a GPS navigation device to acquire position data to locate the user on a road in the unit's map database. Using the road database, the unit can give directions to other locations along roads also in its database. Dead reckoning using distance data from sensors attached to the drivetrain, a gyroscope and an accelerometer can be used for greater reliability, as GPS signal loss and/or multipath can occur due to urban canyons or tunnels.

- A taxi equipped with GPS navigation device

TECHNOLOGY:

Visualization
Road database
Map formats
  CARiN
  S-Dal
  Physical Storage Format
Media
Real-time data
CONTROL OF VEHICLE:

As automotive technology matures, more and more functions of the underlying engine, gearbox etc. are no longer directly controlled by the driver by mechanical means, but rather via a computer, which receives instructions from the driver as inputs and delivers the desired effect by means of electronic throttle control, and other drive-by-wire elements. Therefore, the technology for a computer to control all aspects of a vehicle is well understood.

ELECTRONIC THROTTLE CONTROL:

Electronic throttle control (ETC) is an automobile technology which severs the mechanical link between the accelerator pedal and the throttle. Most automobiles already use a throttle position sensor (TPS) to provide input to traction control, antilock brakes, fuel injection, and other systems, but use a bowden cable to directly connect the pedal with the throttle. An ETC-equipped vehicle has no such cable. Instead, the electronic control unit (ECU) determines the required throttle position by calculations from data measured by other sensors such as an accelerator pedal position sensor, engine speed sensor, vehicle speed sensor etc. The electric motor within the ETC is then driven to the required position via a closed-loop control algorithm within the ECU.

Throttle body with integrated motor actuator

The benefits of ETC are largely unnoticed by most drivers because the aim is to make the vehicle power-train characteristics seamlessly consistent irrespective of prevailing conditions, such as engine temperature, altitude, accessory loads etc. However, acceleration response may occasionally be slower than with cable-driven throttle. The ETC is also working 'behind the scenes' to dramatically improve the ease with which the driver can execute gear changes and deal with the dramatic torque changes associated with rapid accelerations and decelerations.

CHAPTER 5
KEY PLAYERS

INTERNATIONAL:

The European Union has a multi-billion Euro programme to support Research and Development by ad-hoc consortia from the various member countries, called Framework Programmes for Research and Technological Development. Several of these projects pertain to the subject of driverless cars, e.g.: INRIA's La Route Automatisée project gathered much useful data about the actual and possible deployments of Driverless Cars for public transport. The main system discussed is based on FROG.

Many of the EU-sponsored projects are coordinated by a group called Ertico.

GOVERNAMENTS:

USA:

ITS - Turner-Fairbank Highway Research Center

Ice Detection and Cooperative Curve Warning / Current AVCS Deployment - NTL Catalog

UNIVERSITIES AND PROFESSIONAL BODIES:

* UC Berkeley - California PATH

* MIT Media Lab CityCar

* VisLab: Artificial Vision and Intelligent Systems Lab at University of Parma, Italy

* Department of Computing at Imperial College London.

* Virginia Tech

* Austin Robot Technology / UT Austin

    * IEEE has a Society (the Intelligent Transportation Systems Society), runs an important scientific Journal, and organizes conferences

* Japanese Automobile Research Institution
* Advanced Cruise-Assist Highway System Research Organization

* Carnegie Mellon University Navlab

* GrayMatter Inc. - a division of the Gray Team.

* Institute of Autonomous Systems Technology:[24] at Bundeswehr University of Munich

* ACE Lab (Automotive Control and Electronics Lab) at Hanyang University, Seoul, Korea

PRIVATE COMPANIES:

Google driverless car

General Motors EN-V

VOLUNTARY AND HOBBYIST GROUPS:

* Autonomous Robots Magazine


* Open Source Driverless Car Project (Python/C++) http://bitbucket.org/djlyon/smp-driverless-car-robot

CHAPTER 6

IN FILM
* KITT, the automated Pontiac TransAm in the TV series Knight Rider could drive by itself upon command.

* The 1989 film Batman, starring Michael Keaton, the Batmobile is shown to be able to drive itself to Batman's current location.

* The 1990 film Total Recall, starring Arnold Schwarzenegger, features taxis apparently controlled by artificial intelligence; it is not clear, however, whether these are truly autonomous vehicles or simply conventional vehicles driven by androids.

* The 1993 film Demolition Man, starring Sylvester Stallone, set in 2032, features vehicles that can be self-driven or commanded to "Auto Mode" where a voice controlled computer operates the vehicle.

* The 1994 film Timecop, starring Jean-Claude Van Damme, set in 2004 and 1994, has cars that can either be self-driven or commanded to drive to specific locations such as "home".

* Another Arnold Schwarzenegger movie, The 6th Day (2000), features a driverless car in which Michael Rapaport sets the destination and vehicle drives itself while Rapaport and Schwarzenegger converse.

* The 2002 film Minority Report, set in Washington, D.C. in 2054, features an extended chase sequence involving driverless personal cars. The vehicle of protagonist John Anderton is transporting him when its systems are overridden by police in an attempt to bring him into custody.

* The 2004 film I, Robot feature vehicles with automated driving on future highways, allowing the car to travel safer at higher speeds than if manually controlled. An interesting concept of automated driving in this film is that people aren't trusted to drive manually, as opposed by people not trusting automated driving nowadays.

* Anthropomorphic cars (capable of thinking and moving around on their own) have also shown up in movies, such as the series concerning Herbie and the movie Cars. (The name of Volkswagen's 53+1 car was a nod to Herbie; Herbie was conspicuously decorated with the number 53.)
CONCLUSION

As we are going searching and searching new technology we becomes a member advance society.
As we found new technology for the “Driverless Car”, which made our life more easier that finally means: - “Technology- The spice of Life”.