16 An Introduction to Vehicular Systems

Basic Concepts

- Identify and define the six separate systems that make up a vehicular system.
- List safety factors in the design and operation of vehicular systems.

Intermediate Concepts

- Give examples of the components used in each of the six vehicular systems.

Advanced Concepts

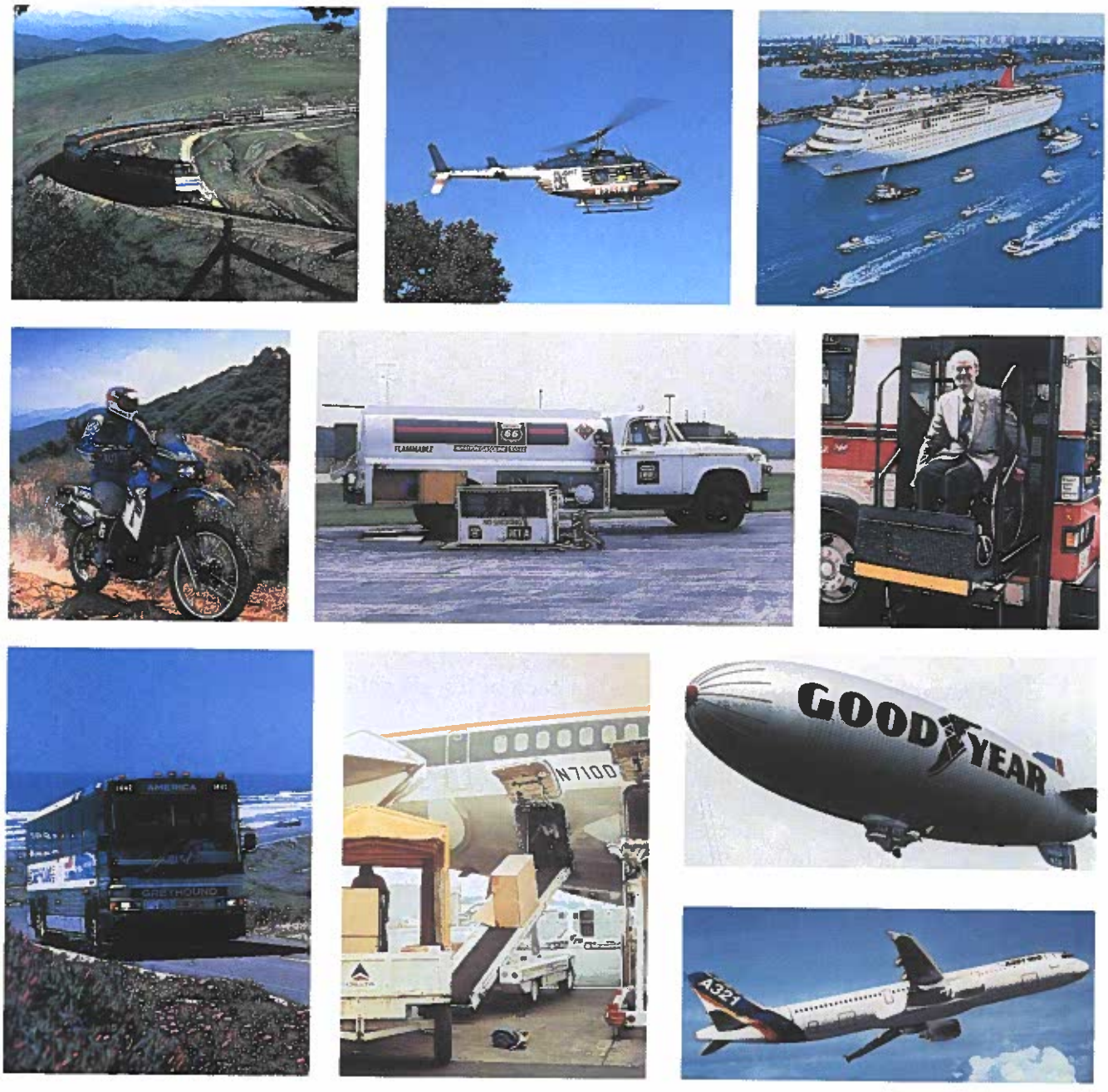
- Describe how global positioning systems (GPSs) operate.

Vehicles are the "machines" that are the basis of our transportation systems. Everyone recognizes that trains are the vehicles used by the railroad industry to transport passengers and cargo. Airplanes are the vehicles employed to move things by companies involved in the air transportation industry. Ships are used for pleasure cruises, as well as for transportation of large quantities of cargo over waterways, both large and small. See **Figure 16-1.**

All vehicles are comprised of a number of different components that allow them to safely transport people and cargo. These components can be placed into six different systems. The ***vehicular systems*** are a collection of separate systems that allow the machine to move through its environment safely and efficiently. These systems are usually part of the vehicle itself, but they may be external, depending on their purpose. The following is a list of the technical components that make up vehicular systems:

- Propulsion systems.
- Guidance systems.
- Control systems.
- Suspension systems.
- Structural systems.
- Support systems.

Figure 16-1. Many different vehicles are necessary to transport people and goods through the four different types of environments. (Amtrak, Greyhound, British Columbia Transit, Carnival Cruise Lines, Kawasaki, Airbus)



Vehicular system: A collection of separate systems that allow the machine to move through its environment safely and efficiently.

These systems will be defined here, but they will be explained in further detail in later chapters.

Propulsion Systems

Propulsion systems are the components of a vehicular system that produce the power needed to move a vehicle. The main function of the propulsion system is to convert energy into mechanical power that can be used to drive, fly, sail, or move a vehicle in some other way. There are

several methods used to convert energy into propulsion, most of which rely on either an engine or a motor. Often the terms *engine* and *motor* are used interchangeably. These devices are, however, different. ***Engines*** are devices that convert heat energy into mechanical energy. ***Motors*** produce mechanical energy by converting electrical energy.

Propulsion system: The components of a vehicular system that produce the power needed to move a vehicle.

Engines

Because engines use heat to produce mechanical power, they are often referred to as *heat engines*. There are several types of engines used in transportation vehicles. Land and water vehicles most often use gasoline or diesel ***piston engines***. See **Figure 16-2.** These engines produce heat by compressing and igniting a mixture of air and fuel. The heat produced pushes a piston, which then turns a crankshaft. The rotating crankshaft is the mechanical power output of the engine. In land transportation, the power is then sent to the wheels in order to move the vehicle. When piston engines are used in water and air transportation, they are typically connected to a propeller. The mechanical energy produced by the engine is used to spin the propeller. The reaction of the air or water to the spinning propeller produces thrust, which moves the vehicle.

Engine: A device that converts heat energy into mechanical energy.

Motor: A device that produces mechanical energy by converting electrical energy.

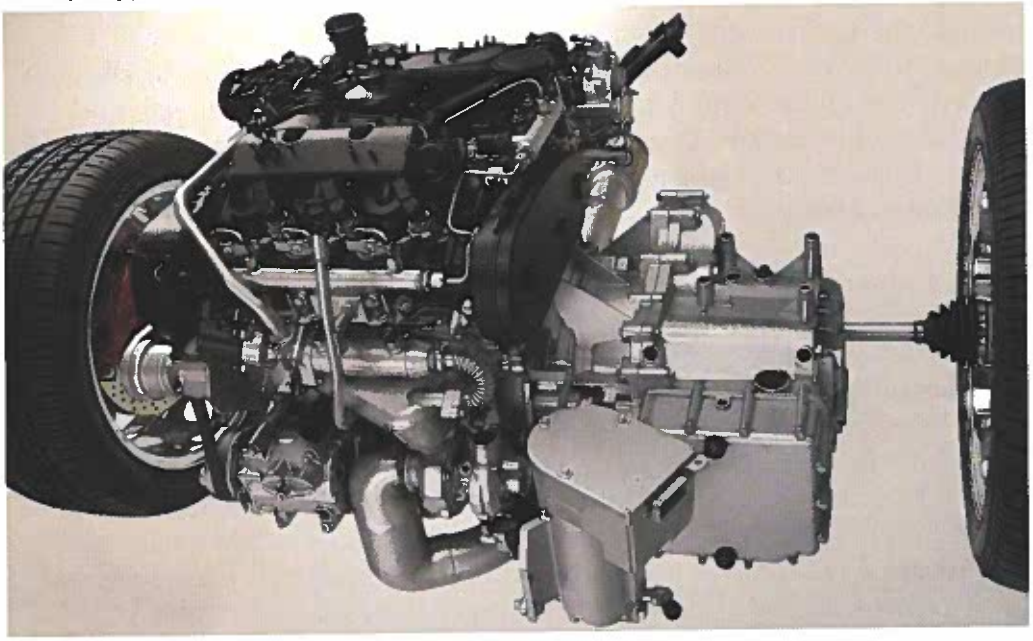
Piston engine: An engine that produces heat by compressing and igniting a mixture of air and fuel.

In air transportation, turbines, rather than pistons, are used most often to convert the energy. The engines used are known as ***jet engines***, or *jet turbine engines*. The jet engines use spinning turbines to compress air. The air is then mixed with fuel and ignited. The high-pressure hot air is sent out the back of the engine, which produces forward thrust. The engines most often used in space transportation are ***rocket engines***. Rocket engines produce thrust by expelling hot gases from a rear nozzle. Igniting chemical propellants produces the gases.

Jet engine: An engine that uses spinning turbines to compress air.

Rocket engine: An engine that produces thrust by expelling hot gases from a rear nozzle.

Figure 16-2. Propulsion systems use energy to provide force that moves vehicles. The automobile, powered by an internal combustion engine such as this one, is the major means of transportation in North America. (Ford Motor Company)



GREEN TECH

Because of the adverse effects gasoline piston engines have had on the environment, newer engines may be equipped with emission-control devices.

Motors

Motors are most often used in land transportation vehicles. Vehicles such as golf carts, bumper cars, light-rail trains, and electric cars use motors as their propulsion sources. The energy supplied to the motor is either direct electricity or electricity stored in batteries. The motors are connected to the wheels and convert the electricity into motion by turning the wheels.

Other Types of Propulsion

Propulsion devices other than engines and motors also power vehicles. Some examples include bicycles, sailboats, and canoes. Bicycles are propelled by human power and a system of gears and a chain. Sailboats are powered by harnessing the power of the wind. Humans using paddles and oars propel canoes.

Guidance Systems

Guidance system: A system that provides the information required to make a vehicle follow a particular path or perform a certain task.

Guidance systems provide the information required to make a vehicle follow a particular path or perform a certain task. The vehicle operator reads these systems and then controls the vehicle according to the information given. There are many sources of guidance information. Street signs, road maps, radio detecting and ranging (radar) screens, and airport runway lights all provide guidance information to the vehicle operator. See **Figure 16-3.** These information sources inform the driver about location, road intersections, distance from other vehicles, and where to land. The driver or pilot must be able, however, to understand the information provided. For example, a radar screen is not very helpful if the operator is unsure about how to interpret the dots and blips on the screen. This is why most vehicles require licenses to be able to legally operate them.

Navigation: The act of guiding a vehicle.

Besides providing information, guidance systems also allow vehicle operators to navigate their vehicles. ***Navigation*** is a word used to describe the act of guiding a vehicle. It usually refers to the guidance of a ship or an airplane, but it may also be used for other vehicles. Navigation has its roots in the Latin words *navis*, which means "ship," and *agere*, which means "to drive." Some of the things a vehicle operator needs to know to ensure he is on the right course include direction of travel, speed, and location of destination. These are all forms of navigation information. See **Figure 16-4.** The operator would also need to know where he is at the beginning of the journey.

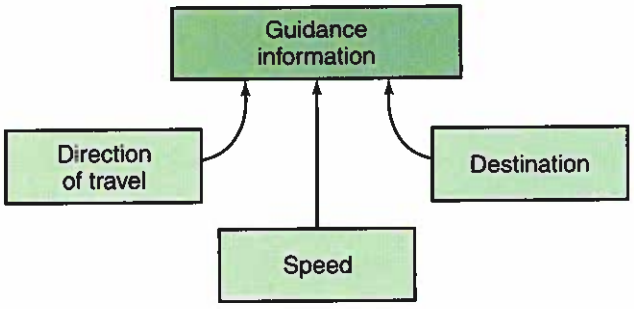
Global positioning system (GPS): A satellite-based navigation system.

Many devices have been used throughout history to determine navigation information (location, direction, and speed). Compasses were the first devices used to determine direction. There are a number of devices specifically used in each transportation environment. ***Global positioning systems (GPSs)***, however, are used in all types of transportation. A GPS is a satellite-based navigation system. It uses a constellation of 27 satellites that transmit signals to the earth. The signals include a timed sequence. Each GPS receiver on earth gathers the signals from several (usually three or four) of the satellites. The receivers are able to determine the location and distance from each satellite. From this information, the receiver can

Figure 16-3. Guidance systems may be part of a vehicle or separate, such as highway signs, runway lights, maps, control towers, and navigation buoys. (U.S. Navy, U.S. Air Force)

determine exactly where on earth it is located. See **Figure 16-5.** Advanced receivers can also track movements, direction, and speed. The GPS is becoming the standard navigation system for most modes of transportation. Many vehicles can be purchased with built-in GPS receivers and electronic mapping software. This makes navigation much easier.

Figure 16-4. Before operating a transportation vehicle, the operator must have these three kinds of information.



Technology Link

Communication: Telematics

Automobiles were designed to move people and goods from one place to another. As technology has advanced, however, drivers have desired their vehicles to perform an increasing amount of communication functions. The answer to this desire is in the area of telematics. Automobile telematics is a technology that allows the automobile and the driver to be connected to others through the use of wireless communication systems.

Currently the most popular automobile telematics system is OnStar® services, by General Motors (GM). OnStar services is an information and safety system installed on over 14 different foreign and domestic brands of automobiles. The OnStar services system has several components. The "brains" of the system is a communications processor. The processor is linked to the automobile's computer, a global positioning system (GPS) receiver, a microphone, air bag sensors, a three-button keypad, a cellular and digital antenna, and the vehicle stereo. The system in monitored by an OnStar services support system.

The system can either be driver initiated or support center initiated. In driver-initiated uses, the driver presses the OnStar services button located on the rearview mirror or dashboard, which calls the support center. The operator at the support center can aid the driver by calling for roadside assistance, providing directions, or on some GM vehicles, even diagnosing vehicle problems. Because the OnStar services system is linked to an onboard GPS receiver, the support center operator can track the vehicle and provide real-time directions. The GPS receiver is also used to track the vehicle when a driver reports her vehicle as stolen. A driver can also call OnStar services operators if he has locked his keys in the vehicle or cannot find his car in a parking lot. Because the system is integrated with the vehicle computer, the OnStar services operator can remotely unlock the door or sound the horn. In other situations, the OnStar services system automatically notifies an OnStar services operator. In accidents in which the air bag is deployed, the system calls an operator. The operator then checks on the condition of passengers and will notify emergency personnel if necessary.

Telematics have progressed beyond the use of OnStar services. Other telematics services include in-dash GPS systems that update wirelessly and built-in docking systems for mobile phones and MP3 players that can be wirelessly connected to various networks. MP3 players may be able to download music and obtain music information wirelessly, while a mobile phone system may include hands-free options. As this wireless technology continues to be developed, it may allow vehicles to be as well-linked as many home offices and game rooms.

Control Systems

Obviously, different vehicles have different abilities, regarding the number of directions in which they can be controlled. For example, a train can only move forward and backward on its tracks, while a helicopter has much more freedom. A helicopter can move forward and backward, left and right, and up and down. The number of changes in direction a vehicle is allowed is called its *degree of freedom*. The train has one degree of freedom, and the helicopter has three. See **Figure 16-6.** There is a wide

Figure 16-5. A global positioning system (GPS) receiver and display unit allow a ship's captain, an airplane pilot, or a truck driver to precisely locate the vehicle's current position.

range of control systems needed to safely operate modern transportation vehicles. Control systems are the parts of vehicles used to change a vehicle's direction and speed.

Changing Direction

Vehicles that are able to move in different directions are normally controlled by the driver or pilot. These vehicles all have devices the operator is able to move in order to steer the vehicle. See **Figure 16-7.** Cars, trucks, and ships have steering wheels. Airplanes have flight sticks and pedals. Space shuttles have hand controllers. All these devices are linked

Figure 16-6. Degrees of freedom. A—Trains must follow tracks. They have only one degree of freedom. (Norfolk Southern Railway) B—A helicopter in flight can move up and down, forward and back, and side-to-side. It has three degrees of freedom.

A

B

Curricular Connection

Language Arts: Translating Information

Technical information is often expressed in a graphic manner because it is easier to express and to understand this information using visual aides or symbols. Several graphic devices are used for this purpose.

Charts and tables are used to organize and compare similar types of information. For example, you can use a chart to compare different types of screws and include information such as length, diameter, and thread. This is easier than reading the information about each screw individually and trying to compare the information.

Another type of visual representation is a flowchart. A flowchart shows the steps of a process in order. A visual representation of a process may be more clear and straightforward than a numbered list of steps.

Schematics are another type of visual representation, using symbols to simplify systems. A common use of schematics is in electrical systems. It would be difficult to write out where each component of an electrical system goes, but it would be even more difficult to try to follow that explanation without visual aides.

Quantitative information is often shown visually in graphs. Different types of graphs, such as pie charts, line graphs, and bar graphs, show information in different ways. For example, a pie chart may show the percentage of people who use various products. A line graph may be used to represent data that was taken over a certain time period. A bar graph may show different types of a product and the amount sold of each. Having this type of information in a graph makes it more easily accessible and easy to read.

Some of the most commonly translated information is mathematical information. Mathematical information uses numbers and symbols rather than words. Once you have learned to read mathematical problems, it is easy to recognize and translate information from numbers to words. For example, when you read a simple math problem, such as $2 + 2 = ?$, you read *two plus two equals blank*, and you know you have to add two and two to find the answer. You have translated the numbers and symbols into words. Other math problems may use letters, or variables, to represent unknown quantities (r for radius) and symbols, such as π, to represent fixed quantities. Once you have learned the meaning of the variable and symbols, you automatically translate them when solving math problems.

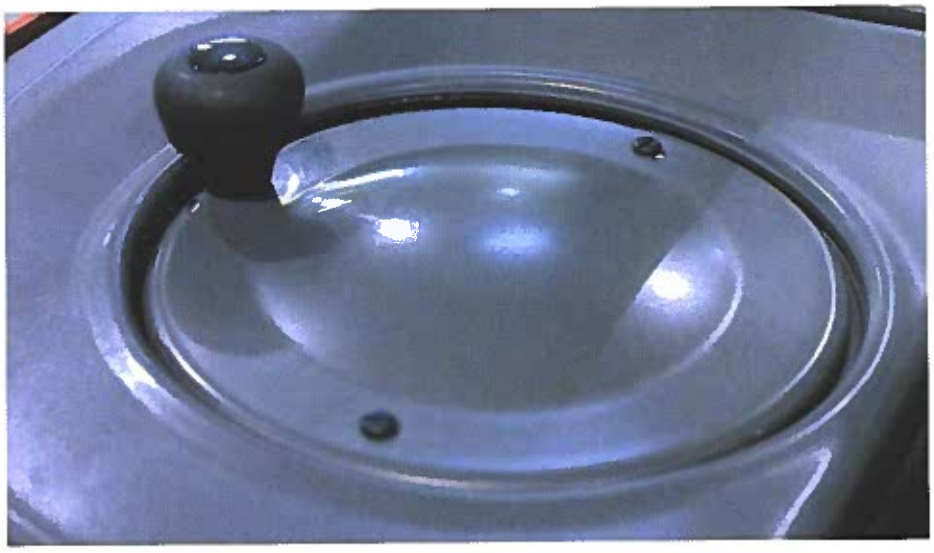
to a steering system, control surfaces, or thrusters that are able to change the direction of the vehicle. Steering systems are common in land vehicles. For example, in an automobile, the steering wheel is mechanically linked to a steering system that turns the wheels as the steering wheel is rotated. Air and water vehicles use moveable control surfaces, which change the vehicle's direction. A common moveable control surface in a boat is a rudder. As the rudder is turned, it forces the boat to turn as well. In space transportation, thrusters are used to change direction and attitude, or rotation.

Figure 16-7. Directional control devices. A—A steering wheel for an automobile. (Mazda) B—An aircraft control stick. (Airbus) C—A "spinner" hand control for an industrial lift truck.

A

B

C



Changing Speed

Accelerator: The part of a vehicle that controls speed by changing the amount of power the propulsion system generates.

Driver and pilots must also be able to control the speed at which the vehicles travel. Speed is controlled in two ways. The first method of controlling speed is by changing the amount of power the propulsion system generates. An ***accelerator*** typically controls this power. In automobiles, the accelerator is the gas pedal. As the gas pedal is depressed, it allows more fuel and air to enter into the engine, which creates more power. In other vehicles, the accelerator is known as the throttle. The second method of changing speed is by applying a braking system. In airplanes and space shuttles, flaps are used as brakes. The flaps are raised during landing to increase the amount of surface area in contact with the air. This helps to slow the vehicle down by creating more drag. Most land vehicles use brakes that come in contact with the wheels. The friction created between the wheel and the brake slows the vehicle down.

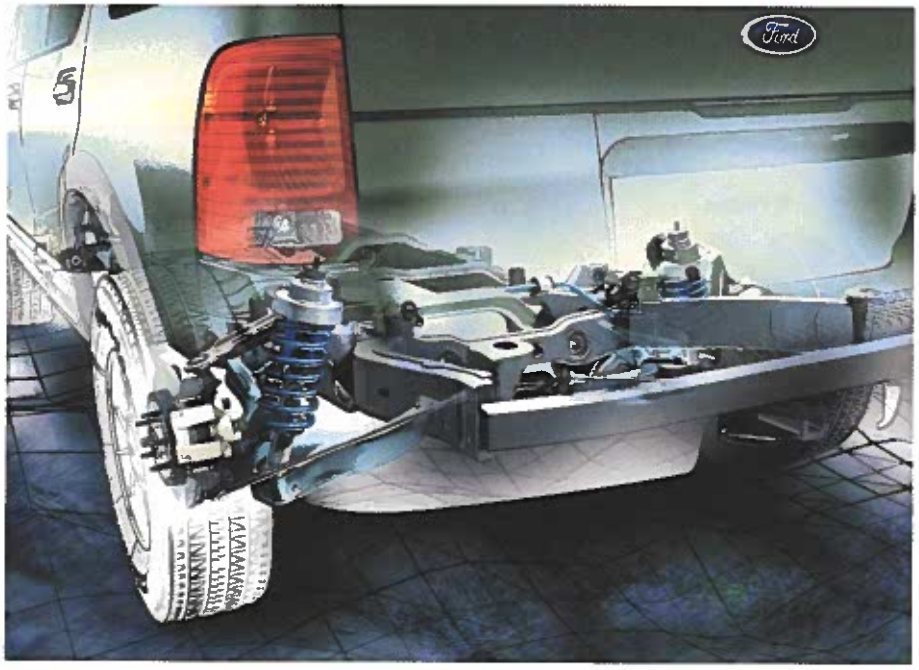
Suspension Systems

Suspension system: The vehicle system that supports or suspends the vehicle in or on its given environment, providing a method to smooth the ride for passengers and cargo.

Suspension systems on vehicles are designed to support or suspend the vehicle in or on its given environment. The suspension systems for vehicles that fly through the air are completely different from the systems used on cars and trucks. Because of the nature of the environments in which they operate, suspension systems obviously need to be different.

These systems also provide a method to smooth the ride for passengers and cargo. Modern automobiles often have special suspension systems so the rides in them are very comfortable. The suspension systems of automobiles include tires, springs, and shocks. See **Figure 16-8.** The three components work together to provide a comfortable and safe ride for the

Figure 16-8. A car's suspension system consists of tires, springs, and shock absorbers. (Ford Motor Company)



passengers. The tires serve as traction and cushioning for the vehicle. The springs help keep the vehicle traveling forward when the tires hit bumps, potholes, or ruts. The shocks are used to dampen the reaction of the springs. In trains, the wheels and springs are contained on what are known as *trucks*, or *bogies*. The trucks are positioned at the front and rear of the railroad cars and pivot as they follow the track.

The main suspension system for water vehicles is the boat hull. The hull is the underside or lower body of the boat. When sitting in water, boat hulls must be designed to displace their weight in water. For example, if a boat weights 1 ton, it must displace, or push aside, at least 1 ton of water to stay afloat.

Airplane suspension relies on the wings to generate lift. ***Lift*** is the force that keeps aircraft in the air. The wings have an airfoil shape specially designed so, as the wing travels through the air, lift is generated, and the airplane is able to fly. As airplanes land, they require landing gear similar to land vehicle suspension systems (tires and shocks). The landing gear enables the plane to land safely and move from the runway to the gate.

Lift: The force that keeps aircraft in the air.

Possibly the most unique suspension system is that of magnetic levitation (maglev) vehicles. See **Figure 16-9.** Maglev vehicles are suspended from a guideway, or track, by a magnetic field. The magnetic field is generated by electromagnets on both the vehicle and the guideway. This creates a frictionless cushion of air on which the vehicle can travel.

Structural Systems

Structural systems are the parts of vehicles that hold other vehicular systems and the loads they will carry. In most cases, vehicular structures need to be strong and rigid. They provide mounting places for propulsion, control, suspension, and some guidance systems. Structural systems also

Structural system: The parts of vehicles that hold other vehicular systems and the loads they will carry.

Figure 16-9. A magnetic levitation (maglev) train is held suspended above its guideway by magnetic forces. This is an artist's conception of a maglev train (upper level) in the main railroad station in Munich, Germany. The maglev line, now under construction, will connect the railway station and the city's airport. (Transrapid International, Inc., GmbH)

GREEN TECH

Maglev trains may be considered environmentally friendly, not only because of their energy efficiency, but also because the land needed for a maglev system is so much less than that of traditional railroads.

provide the "skin" of the vehicle, which protects the systems, passengers, and cargo from the environment. The environment includes rain, hail, mud, and extremes of heat or cold.

Structures also provide protection from hazards that come about as a result of transportation in society. There is always a danger of accidents. Structural systems are designed to take passenger safety into account. Thorough structural testing is done on most vehicles to improve passenger safety. See **Figure 16-10.**

Most vehicle structures are made of a frame and a body. The frame serves as the connecting place for other vehicle systems and components. For example, the frame of a satellite, known as a bus, serves as a structure for attaching solar panels, thrusters, and antennas. The body of the vehicle is a shell that encloses the vehicle. It usually determines the shape of the vehicle. Car bodies are a good example. See **Figure 16-11.** You are aware of the many styles and shapes automobiles have. Some are plain and basic shapes. Others are flashy, sporty, and even exotic looking. No matter what their styling, one of the functions of cars is to protect their occupants.

The structure of the vehicle often determines the purposes the vehicle serves. In railroad cars for example, the structure could be designed as a hopper car that carries coal, a flatbed that carries large equipment, or a

Figure 16-10. Structural testing. A—Automobile manufacturers conduct crash tests to determine the structural safety of their vehicles. (General Motors) B—Aircraft are crash tested to learn how fabrics and other materials resist burning. (National Aeronautics and Space Administration)

A

B

STEM Connection

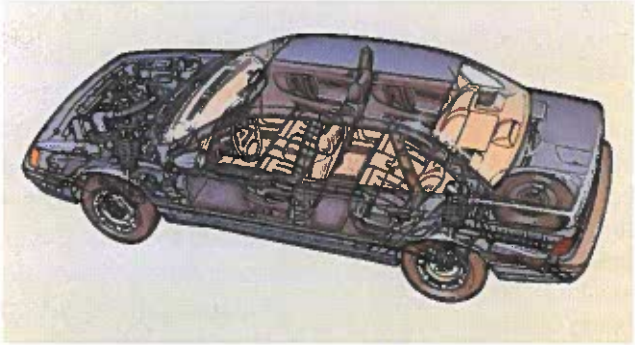
Technology: Safety in Vehicular Systems

Human life is highly valued. Because of this, the design and manufacturing of vehicle systems has evolved with increasing emphasis on built-in safety. We often think of devices such as seat belts, air bags, antilock brakes, warning systems, and drop-down oxygen masks when we consider vehicle safety. The actual structure of vehicles, however, often includes safety features as well. Front and rear crumple zones are designed to collapse and absorb the force of an impact. Other safety oriented structural components include new car windshields, chassis configurations, and flame-retardant materials used in airplane upholstery. Vehicle designers study the results of crash tests, as well as actual accidents, to determine better ways of constructing vehicle systems.

car carrier that transports automobiles. In water transportation, the structure of the hull and the decks of ships and boats can also be designed to serve a number of purposes. The structure of a ship can be designed to carry passengers, in the case of a cruise ship, or cargo, in the case of a containership.

Most vehicle structures are made of steel and other metal alloys, so they are very strong and durable. Plastics and composite materials have also been used by the industry to save weight and enhance the appearance of some vehicles. Advancements in structural designs have made vehicles safer and more efficient.

Figure 16-11. Structural systems provide a body, or support, for all other systems of the vehicle. They also protect the passengers and cargo. (Saab)



Support Systems

Support systems include all the external operations and facilities that maintain transportation systems. These include passenger and cargo handling, roadway construction, maintenance, life support, economic support, and even legal support. See **Figure 16-12.** Support systems are essential for the operation of any vehicle. Most support systems are not a part of the actual vehicle. Even so, they are an important link in transportation technology.

Support system: The external operations and facilities that maintain transportation systems.

Figure 16-12. Support systems provide protection, services, and repair facilities for vehicular systems. A—A quick-change oil station. B—Railcar repair. (Amtrak) C—Truck stops allow vehicles to refuel and drivers to take meal breaks. D—Rest stops along interstate highways provide drivers with information, restrooms, and sometimes fuel and food services. E—Ports include facilities for loading and unloading ships, as well as for storage of cargo. (Port of Long Beach) F—Repair equipment keeps roadways in good condition.

A

B

C

D

E

F

GREEN TECH
Traditional soil stabilizers, such as lime, that are used in road foundations, may require large amounts of water and leak chemicals into the ground. Soil stabilizers that consume less water and reduce chemical emissions are now available and are being used in construction of some new roads and highways.

One of the more obvious support systems for land vehicles is the road and highway network. Without this system of paved, or hard-surfaced, roads, vehicle travel would be uncomfortable and unsafe. Vehicles would not be able to travel at the speeds they do today. For rail vehicles, the same can be said of the system of rail beds and tracks connecting various communities throughout the country. Obviously, this transportation system would be useless without railroads.

Air transportation industries rely on airports. Runways and terminal buildings are important support systems. Overseas and inland shipping companies need harbor and port facilities so they can move their cargo from water to land. People in the shipping industry would have no way to receive or deliver cargo or passengers without access to harbor facilities.

Transportation industries would not be able to survive or compete without support services. People would not be able to own or operate automobiles without support services. Vehicles and their systems are only a part of the whole transportation story. Support systems include all the parts of society devoted to sustaining transportation technology and the ability of people to use it. Although support systems are not a direct part of the vehicles themselves, they are very important.

Career Connection

Automotive Service Technicians

Vehicles are only beneficial if they are in working order. Automotive service technicians accomplish the job of maintaining and repairing cars and light trucks. Automobile dealerships, government organizations, or independent repair shops typically employ service technicians.

The job of an automotive service technician is to diagnose, service, and repair cars and trucks. In order to do so, service technicians must understand diagnostic equipment. Much of the diagnosis is done using electronic and computerized equipment that requires an understanding of electronics. Once the problem has been located, the service technician must then have the ability to use hand and power tools to remove and replace the damaged parts. The hand tools used by service technicians are often the most expensive part of entering into the field. Service technicians are typically expected to provide their own hand tools, while the company they work for supplies the diagnostic equipment and computerized scanners.

The job of a service technician is geared toward people who have a mechanical aptitude and strong analytical skills. Most service technicians begin training in automotive repair classes in high school vocational programs. A great majority then attend a postsecondary vocational or technical school or a community college. Most programs range between 12 and 24 months in length and lead to a certification. Several of the automobile manufacturers provide additional training to the top technical school students. After graduation from an automotive service program, the job market provides good opportunities. The majority of service technicians make between $12 and $21 per hour. Once service technicians have gained several years of experience, they can work at becoming certified by the National Institute for Automotive Service Excellence (ASE). Technicians must have work experience and pass a written exam to become ASE certified in one of eight areas. A service technician that becomes certified in all eight areas is known as an ASE Master Automotive Technician.

Summary

Vehicles can be considered the most important part of transportation in our society. Without them, fast, safe, and efficient movement of people and cargo would not be possible. Vehicular systems are a series of separate, but interrelated systems. The separate components include propulsion, guidance, control, suspension, structure, and support systems. Many of these components are a part of the vehicle itself, although some are not. Support systems include a broad range of facilities and services that are very important to transportation technology in our society.

Key Words

All the following words have been used in this chapter. Do you know their meanings?

accelerator
engine
global positioning system (GPS)
guidance system
jet engine
lift
motor
navigation
piston engine
propulsion system
rocket engine
structural system
support system
suspension system
vehicular system

Test Your Knowledge

Write your answers on a separate sheet of paper. Do not write in this book.

1. _____ are the machines that transportation systems use to move passengers and cargo safely, swiftly, and efficiently.
2. Explain the difference between an engine and a motor.
3. List three types of navigation information.
4. A(n) _____ uses a constellation of satellites to determine the location on earth.
5. Describe the term *degrees of freedom*.

Matching questions: For Questions 6 through 11, match the phrases on the left with the correct term on the right.

6. _____ Vehicle components that provide methods for using energy to propel vehicles.
7. _____ Systems that provide information required by a vehicle to make it follow a certain path.
8. _____ Parts of vehicles that provide methods for changing speed and direction.
9. _____ Systems that provide a smooth ride for passengers and cargo.
10. _____ Parts of vehicles that contain other systems and protect passengers and cargo.
11. _____ All external operations that maintain vehicle and transportation systems.

A. Control systems.
B. Guidance systems.
C. Propulsion systems.
D. Structural systems.
E. Support systems.
F. Suspension systems.

STEM Activities

1. Secure a picture of a lawn mower, and then draw arrows to its different parts. Label each part with its proper name. After the name of each part, write what subsystem of the vehicular system it is.
2. On a sheet of paper, list all the propulsion systems you can. After each system, write down the environment (land, water, air, or space) for which it is suited.
3. Design and construct a working model of a land vehicle that includes all or as many subsystems as you can devise.