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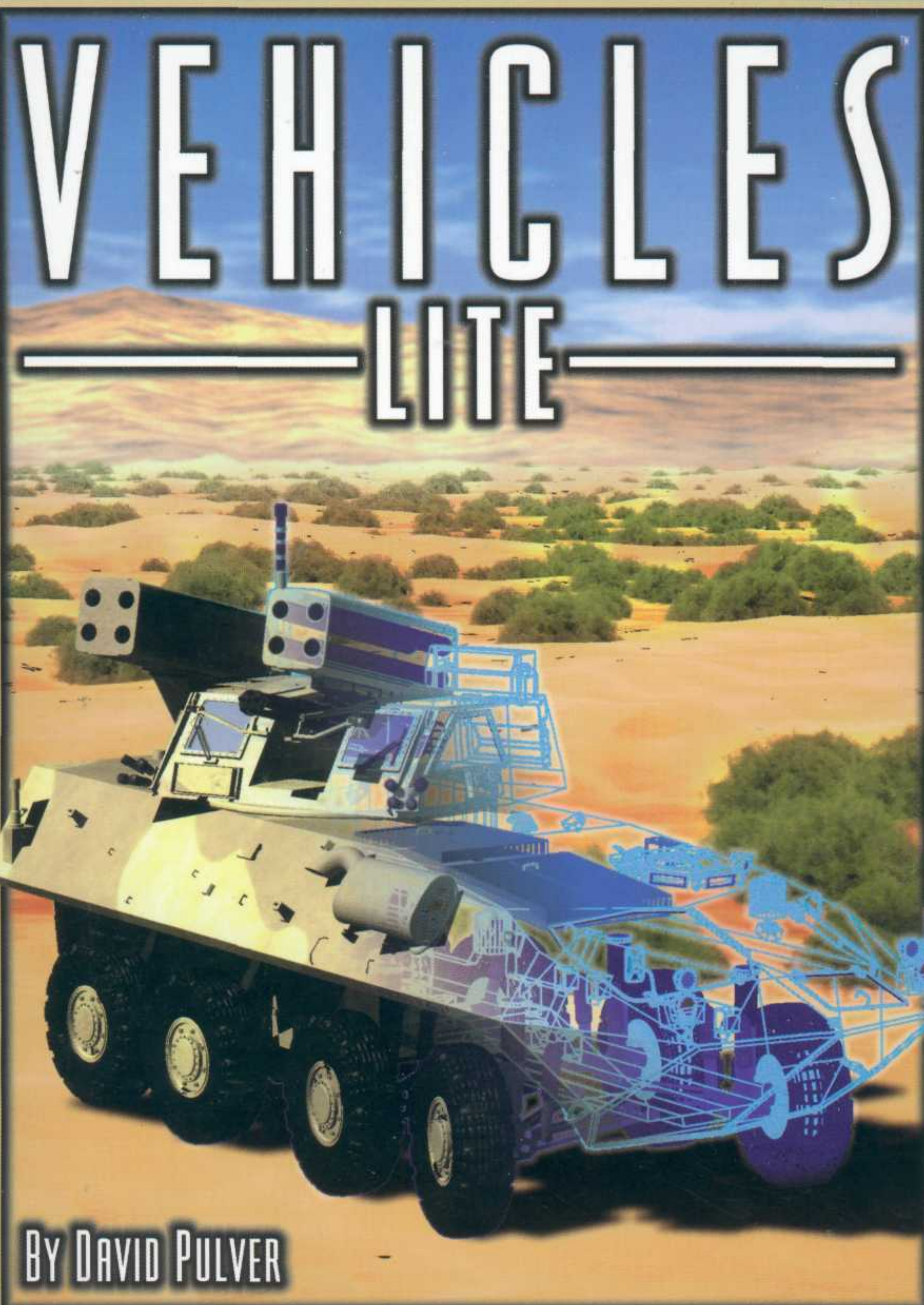
VEHICLES™

LITE



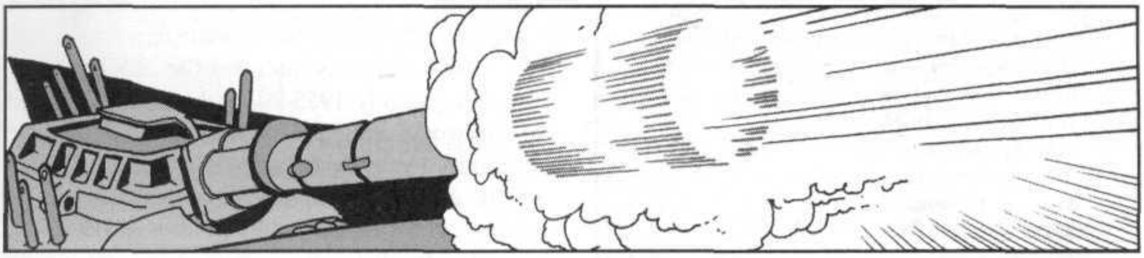
BY DAVID PULVER

STEVE JACKSON GAMES

GURPS®

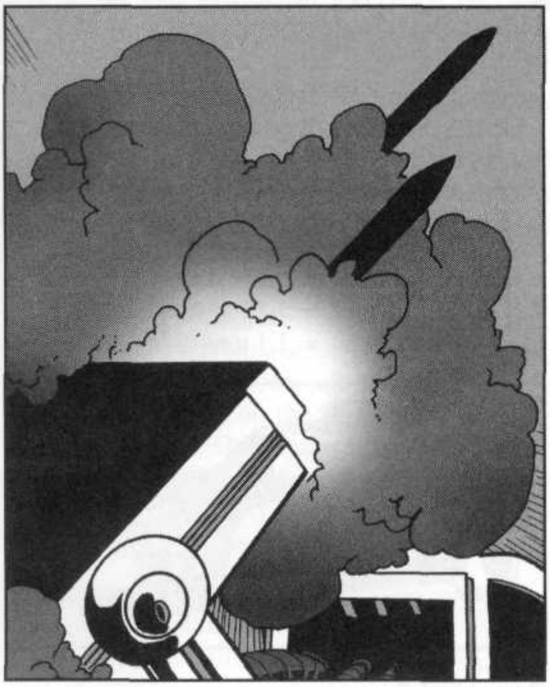
VEHICLES LITE™

HOT WHEELS AND HEAVY METAL



BY DAVID PULVER

Edited by Graeme Davis and Kenneth Peters • Cover by Jesse DeGraff
Illustrated by Dan Smith • Additional illustrations by Justin De Witt



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STEVE JACKSON GAMES

INTRODUCTION

About GURPS

Steve Jackson Games is committed to full support of the *GURPS* system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources include:

Pyramid (**www.sjgames.com/pyramid/**). Our online magazine includes new *GURPS* rules and articles. It also covers ***Dungeons and Dragons, World of Darkness, Call of Cthulhu,*** and many more top games – and other Steve Jackson Games releases like ***In Nomine, Illuminati, Car Wars, Toon, Ogre Miniatures,*** and more. *Pyramid* subscribers also have access to playtest files online!

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. A current catalog is available for an SASE. Or check out our website (below).

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are available from SJ Games; be sure to include an SASE. Or download them from the Web – see below.

Gamer input. We value your comments, for new products as well as updated printings of existing titles!

Internet. Visit us on the World Wide Web at **www.sjgames.com** for an online catalog, errata, updates, Q&A, and much more. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. This e-mail list hosts much of the online discussion of ***GURPS.*** To join, e-mail majordomo@io.com with "subscribe GURPSnet-L" in the body, or point your web browser to **gurpsnet.sjgames.com**.

The ***GURPS Vehicles Lite*** page is **www.sjgames.com/gurps/books/vehicleslite/**.

Page References

Any page reference that begins with a B refers to the ***GURPS Basic Set****, Third Edition.* CI refers to ***GURPS Compendium I*** and CII to ***GURPS Compendium II.*** The abbreviation for ***GURPS Vehicles Lite*** is VEL. See p. CI181 for a list of abbreviations for ***GURPS*** titles, or see **www.sjgames.com/gurps/abbrevs.html** for the most recent list.

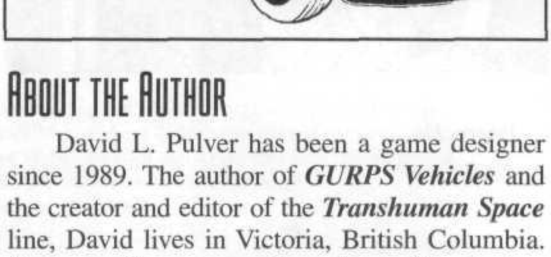
GURPS Vehicles Lite contains rules for using and creating modern-day wheeled, tracked, and rotary-winged vehicles for contemporary campaigns such as ***GURPS Cops, Espionage, Horror, Special Ops,*** or ***Supers***. This book covers both civilian and military designs: You can build cars, trucks, cycles, racing cars, or even attack helicopters and main battle tanks!

Vehicles Lite is intended for contemporary vehicles (roughly 1955-2010), but it's not limited to real-world designs. Use ***Vehicles Lite*** to create customized vehicles for spies and supers, or create unique designs for near-future or alternative Earth settings, or for TL7 societies on other planets.

This book is also intended to provide an accessible primer for the more complex ***GURPS Vehicles,*** *Second Edition,* whose 208 pages provide a comprehensive system for everything from chariots to starships.

Metric Unit Conversions

1 meter =	1.09 yards or 3.28 feet
1 kilometer =	0.621 miles
1 cubic meter =	35.3 cubic feet
1 liter =	0.264 U.S. gallons
1 horsepower =	0.746 kilowatts
1 kilogram =	2.2 pounds
1 kph =	0.621 mph
1 knot =	1.15 mph
1 metric ton =	1.1 tons (2,200 lbs.)



About the Author

David L. Pulver has been a game designer since 1989. The author of ***GURPS Vehicles*** and the creator and editor of the ***Transhuman Space*** line, David lives in Victoria, British Columbia. He has written or co-authored over 50 roleplaying games, adventures, and supplements.

How Vehicles Work 1

GURPS Vehicles Lite concerns itself with modern automotive vehicles, for road and off-road travel, and helicopters. This chapter explains terminology and jargon to make it easier to design and use vehicles based on "real world" technology.

Motor Vehicles

These are wheeled and tracked self-powered ground vehicles: automobiles, motorcycles, trucks, bulldozers, tanks . . .

Wheeled Vehicles

Wheels are the motive system of choice for ground vehicles. Running on rubber tires and with a modern suspension system, they are inexpensive, easy to maintain, and permit high speeds across roads and similar hard-surfaced terrain. Vehicles with all-wheel drive transmissions and/or larger wheels and heavy-duty suspensions can also have credible off-road performance.

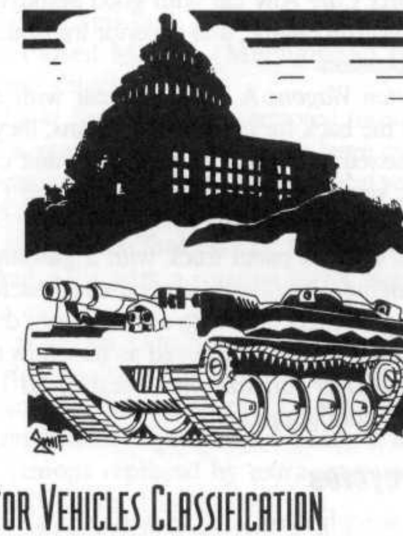
Their disadvantages include the vulnerability of their tires – to debris or to hostile fire – and their high ground pressure compared to tracked vehicles, which limits the off-road capabilities of wheeled heavy trucks and armored vehicles.

Most automobile-sized or larger wheeled vehicles have a stable arrangement of four, six, or eight wheel positions (albeit sometimes with multiple wheels on the same axle, as in large semi-tractors). On a large vehicle, six or more wheels mean less agility but greater stability, as it can keep a relatively low profile rather than riding high like a monster truck.

Tracked Vehicles

Tracked vehicles use a pair of caterpillar tracks. The motive system consists of two sets of "road wheels" and smaller bogie wheels, all without tires, collectively known as running gear. Each supports a flexible belt of rubber-coated steel plates that forms a continuous band. These caterpillar tracks are wider than any tire, and have far lower ground pressure. They also allow the vehicle to clamber over ditches and obstacles.

Tracks are used for heavy construction equipment such as bulldozers and power shovels, as well as armored fighting vehicles. They are less vulnerable to damage than tires, although it is possible for material to jam in the running gear, causing the vehicle to "shed" a track. Tracked vehicles can also be built with a lower silhouette than off-road wheeled vehicles. Their disadvantages are a slower road speed, greater weight and expense, and higher maintenance requirements. Heavily loaded tracked vehicles, such as tanks, also tend to wreck road surfaces.



Motor Vehicles Classification

There are numerous different kinds of motor vehicles, including . . .

Passenger Cars and Light Trucks

The dominant vehicles on the roads are four-wheeled autos and light trucks, typically powered by a gasoline internal combustion engine (p. 7). Subtypes include:

Coupe: A two-door automobile, with a seat for driver and passenger in front, and usually cramped or no rear seats. Coupes are often sports cars.

4×4 Vehicle: A jeep or other off-road vehicle with four-wheel or all-wheel drive and a rugged suspension. May have an open or enclosed cabin.

Limousine: A chauffeur-driven luxury sedan, with its back-seat passenger compartment partitioned off from the front seats. Very roomy "stretched" limousines exist.

Luxury Car: A large, costly, quality vehicle.

Pickup Truck: A light truck with cab seating for two or three, a robust frame, and, sometimes, all-wheel drive. It has an open cargo bed in back.

Police: A luxury sedan or van with, at minimum, a partitioned back seat to secure prisoners, emergency lights and siren, a two-way radio, and a more powerful engine.

Sedan or Saloon Car: A sedan is an enclosed passenger car, usually with four doors and seats for a driver and three to four passengers. American sedans are often classified by their combined occupant and cargo volume in cubic feet (cf): minicompact (84 or fewer cf), subcompact (85-99 cf), compact (100-109 cf), midsize (110-119 cf), or large (120+ cf).

Sport Utility Vehicle (SUV): Automotively similar to a pickup truck or 4×4, but with a station wagon-type body seating three to seven passengers and good internal cargo space.

Sports Car: Any car with good aerodynamics, a powerful engine, and superior transmission and suspension.

Station Wagon: A sedan-like car with extra room in the back for cargo. Like sedans, they are often classed by combined passenger and cargo volume: small (130 or fewer cf), midsize (130-159 cf), or large (160+ cf).

Van: A light panel truck with a gasoline or diesel engine. Usually has a good-sized enclosed cargo or passenger area with a rear door or doors, and sliding side doors. Classed as minivans (seat up to seven) or full-size vans (seat up to 15 in passenger configurations).

Motorcycles

A two-wheeled vehicle with a cycle seat, usually powered by a gasoline engine. Two-wheeled cycles are practical because their light weight and open saddles allow the rider to use his own body to balance and stabilize the vehicle. Subtypes include:

Dirt Bike: Any motorcycle designed for off-road operations or off-road racing.

Motor Scooter: A small bike with a relatively small engine (some only developing 2-10 horsepower), suitable only for a single rider.

Light, Commuter, Police, Touring, or Sporting Motorcycle: A motorcycle that can carry two people. Categories generally refer to engine size, with bigger engines (60+ kW/80+ horsepower) on police, touring, and sports bikes.

Commercial and Oversized Vehicles

Agricultural, Earth-Moving, and Construction Vehicles: These include bulldozers, power shovels, cranes, farm tractors, harvesters, and so on. They have a heavy body with off-road wheels or tracks, with open or exposed seating for one operator, and use a diesel engine.

Bus: An oversized vehicle designed to carry passengers rather than cargo. Large "transit," "school," or "tour" buses seat 30 to 60 people, while small "airport" or "commuter" buses seat 15 to 30. Most have four wheels with diesel engines.

Heavy Truck: A large commercial vehicle designed to carry cargo or equipment itself rather than pull a trailer. Most have four or six wheels and a diesel engine. Common body styles are van (with an enclosed cargo area), flat bed (open cargo), reefer (refrigerated), tanker, dump truck, and vehicle transporter. More specialized heavy trucks are used to mount additional equipment: cranes, cherry-pickers, fire fighting gear, cement mixers, street cleaning brushes . . .

Motor Home, Caravan, or Recreational Vehicle (RV): A large four- to six-wheeled vehicle with living quarters (typically two beds, a dining room, and bathroom). It also has a tank to supply drinking water and a sizable battery.

Sport and Competition Vehicles

All-Terrain Vehicle (ATV): A small single-seat vehicle with off-road suspension and all-wheel drive, exposed seat, and an open frame rather than enclosed body.

Dune Buggy: A larger two-seat or three-seat ATV.

Monster Truck: A "stock racer" pickup truck or SUV extensively modified through the addition of a powerful engine and drivetrain and massive wheels.

Open-Wheel Racer: A custom-built racing car (such as a Formula 1 racer, dragster, or Indy car) whose aerodynamic body has small wings that exert a downward force to glue it to the track at high speed. The driver sits in an open seat. Its 500+ kW/700+ horsepower fine-tuned engine must be virtually rebuilt after each race.

Racing Bike: A sports motorcycle or dirt bike with a more powerful engine and improved suspension, suitable for competition events.

Stock Racer: A vehicle whose body resembles a mass-production model, but which has been stripped down and modified for competition; e.g., with only one seat, or a highly tuned high-performance engine. NASCAR racers are "stock cars."

Panel Truck or Van: A basic delivery truck. Military versions may be a bit more rugged, with off-road suspensions. Trucks are often described by how much they can carry, e.g., 2.5-ton truck; this is not the weight of the vehicle itself.

Riot Vehicle: A wheeled vehicle, usually the size of a full-size van or heavy truck, fitted with run-flat tires and enough armor to stop rifle fire and grenade fragments. It will have gun ports, a passenger compartment that can carry several riot police, and, often, a turret with a water cannon and/or grenade launcher.

Semi-Tractor or Prime-Mover: A big three-axle, 10-wheeled vehicle with a powerful diesel engine and a "fifth wheel" onto which the semi-trailer is hitched. Semi-tractor cabs usually seat two people; "sleeper" designs add bunk space for long hauls.

Semi-Trailer: A long (often 40' or 48'), eight-wheeled heavy-duty trailer designed to be hitched to a semi-tractor. Common types are flat bed (open cargo), container (an enclosed cargo container), refrigerated ("reefer"), tanker, and vehicle transporter.

Truck: A "truck" is distinguished from a semi-tractor in that its payload is part of the vehicle, rather than towed by it. They range from pickups to heavy trucks.

Armored Fighting Vehicles (AFV)

An AFV is a vehicle designed to survive and fight on the battlefield. Most AFV are constructed of steel or aluminum alloy, with armor that is integral to their frame and, at minimum, proof against small-arms fire and shell fragments. Most also have a machine gun in an open "pintle" mount on the roof or in a revolving turret.

Crew is usually a driver, a commander, a gunner if the AFV carries more than a single machine gun, and, on tanks that require it, a loader. Turreted AFV usually seat the driver and any passengers in the body and other crew in the turret.

AFVs have four to eight off-road wheels and all-wheel drive, or a pair of caterpillar tracks. Most have diesel or multi-fuel engines, although some use turbines. Light AFVs weighing under 15 tons can be carried by tactical transport airplanes or dropped by parachute, while 70 tons is seen as the practical upper limit for heavy AFVs, to avoid collapsing bridges. AFV types include:

Armored Car: A wheeled AFV, generally with a turret-mounted machine gun or cannon. Usually lightly armored.

Armored Engineering Vehicles: These are bulldozers, bridge-layers, power shovels, and recovery (towing) vehicles, armored to survive under fire. They are often converted tanks.

Armored Personnel Carrier (APC): A "battle taxi" built to transport an infantry squad (7 to 14 soldiers) to the edge of the battlefield, while protecting against artillery fragments and small arms fire. It usually has a two-person crew and is armed with a machine gun. APCs are often modified for other roles, e.g., armored ambulances, mobile command posts, or self-propelled artillery (with mortars).

Heavy Assault Carrier: An APC or IFV built using the hull of an old main battle tank, with the turret removed and extra add-on armor. Intended for city fighting.

Infantry Fighting Vehicle (IFV): An APC-like vehicle that is also capable of fighting other AFVs. It carries a smaller squad, has slightly better armor (with frontal protection against autocannon), and mounts a rotating turret with an automatic cannon, machine gun, and (sometimes) an anti-tank guided missile launcher. Also called MICVs (Mechanized Infantry Combat Vehicles).

Light Tank: A lightly armored tracked AFV with a rotating turret mounting a large cannon or autocannon and machine guns. Typical weight 10 to 35 tons.

Main Battle Tank (MBT): A heavily armored tracked AFV with a rotating turret mounting a large caliber tank cannon and machine guns. Typical weight 35 to 70 tons.

Reconnaissance Vehicle: A vehicle intended for scouting and hit-and-run "cavalry" or "armed reconnaissance" operations. Usually a modified IFV (troops replaced by extra ammunition or sensors), armored car, or light tank.

Self-Propelled Artillery: A lightly armored AFV with a turret or open mount armed with a 80 to 120mm mortar or other large indirect-fire weapon. This also includes specialized anti-aircraft or air-defense vehicles with targeting radar, missiles, and/or rapid-fire autocannon in "universal" mounts (that can hit both air and ground targets).

Helicopters

Helicopters have grown in importance over the last 50 years, and are now indispensable for tasks ranging from news gathering to search-and-rescue to special operations.

The key to their success is their use of a rotary rather than fixed wing, which enables the helicopter to take off and land vertically, or hover in mid-air.

Helicopter Aerodynamics

An aircraft generates lift aerodynamically via the motion of its wings through the air. Its wing is shaped so that the flow of air over the wing travels faster than the air passing under it. The faster air moves, the lower its pressure. Because the air under the wing is moving slower, it is at a higher pressure than the air immediately above it. As a result, the air under the wing tries to rise upward, and this results in lift, buoying the aircraft up. If the wings can move fast enough, their motion will result in enough lift to counter the aircraft's own weight, and the aircraft will lift into the air and take off.

Ordinary "fixed wing" aircraft move their wings fast enough to achieve lift by taxiing along the ground at high speed, driven by jets or propellers. Once in the air, they must maintain a minimum speed – often at least 50 to 100 mph – or they'll stall and fall out of the sky. This requirement means that a normal airplane must be in constant motion, and must have a lengthy, flat runway to land and take off.

Helicopters were designed to get around that limitation. A helicopter is a "rotary wing aircraft." Instead of a fixed wing, it uses a set of rotating blades, mounted atop the vehicle. The blades' rotation is powered by an engine, through a specialized transmission. Because the powered rotary wing's motion is independent of the vehicle's own speed, a helicopter can achieve lift even when it is stationary. This lets it take off or land vertically, or stop and hover in mid-air. The helicopter moves forward (or in other directions) by tilting the rotor or the helicopter itself. This lets the main rotor(s) function like a giant propeller, moving the vehicle along at high speed.

The major limitations on helicopters are speed and payload. Rotor design imposes fundamental aerodynamic limits on how fast helicopters can go and how much payload or fuel they can carry, in comparison to fixed-wing aircraft. Most helicopters are built to have top speeds of 125-200 mph; a speed in excess of 300 mph is impractical.

Helicopter Rotors

There are several different types of helicopter rotor designs. The most common are:

Top-and-Tail Rotor (TTR): The most common design, it uses a large two- to six-bladed main rotor mounted above the helicopter's body for lift and propulsion. However, a rotor turning in a single direction produces torque, which would cause the helicopter to spin! To prevent this, a small rotor or ducted fan, geared to the main rotor, is mounted on a tail. The tail rotor produces a lateral thrust countering torque.

Multiple (or Tandem) Main Rotor: This is commonly used on very large helicopters. It uses two big main rotors atop the vehicle, usually one near the front, and one, slightly higher, near the rear. They turn in opposite directions to cancel torque. This gives better speed and lift at the expense of agility and weight.

Coaxial Rotors (CAR): These use a single rotor shaft with twin sets of blades rotating in opposite directions around it. CAR systems are a bit heavier than TTR systems, but the absence of a tail rotor somewhat improves maneuverability. Other "no tail rotor" designs with different technology also exist; CAR also represents these.

Helicopter Types

Light Helicopters: These are small helicopters, usually with top-and-tail rotors. Typical applications are news gathering, executive transport, police and border patrol, aerial cinematography, and support of offshore oil rigs. They usually seat two to eight people and weigh 3,000 to 6,000 lbs. loaded. Smaller two- to four-seat models often have internal combustion engines that are about as powerful as auto engines. The upper end of the light helicopter market are turbine-engine models like the Bell 206 Jetranger.

Medium Lift and Utility Helicopters. These are multipurpose machines capable of carrying more passengers or cargo; commercial designs are often based on military models or have a military version. Most have a top-and-tail rotor system, but they often use two engines for extra power and reliability. They typically seat 10 to 20 people or carry two to four tons of cargo, and weigh 7,000 to 12,000 lbs. They are used for the same jobs as light helicopters, as well as assault transport, air ambulances, search and rescue, and firefighting. Some military versions are very similar to civilian designs, but others add door-mounted machine guns and, especially in newer models, night vision gear, inertial navigation systems, self-sealing fuel tanks, and armor. Examples include the Bell UH-1 Iroquois (the "Huey"), the Bell 412, and the Agusta Westland EH101 Merlin.

Heavy Lift Helicopters: These are large helicopters, mostly twin-engine, and often with dual main rotor assemblies. Some carry 30 to 60 people or 5 to 10 tons of cargo. Uses include assault transport, forestry, firefighting, and transport of heavy equipment to remote areas. They can often carry large cargos in a sling under the vehicle (such as a howitzer or light truck). Examples are the Boeing Vertol CH-47 Chinook and the Sikorsky S-64 Skycrane.

Attack Helicopters: These "gunships" escort troop-carrying, rescue, and medivac helicopters, provide fire suppression for helicopter landing zones, and battle other helicopters. They are also the most lethal tank killers on the battlefield. Some gunships are modified light or utility helicopters, but most are skinny, purpose-built machines with two-person cockpits, "stub wings" to attach rockets and missiles, and sometimes a "chin turret" under their nose with autocannon or grenade launchers. They are armored to resist machine gun fire, and possess sophisticated sensors and ECM. Examples are the Hughes AH-64 Apache and the Kamov Ka-50 "Black Shark."

Scout Helicopters: These are built or modified for military reconnaissance, light attack, or counter-insurgency operations. Most are upgraded light helicopters, typically with additional sensors, sometimes including a mast-mounted sight (p. 48), and two to four hardpoints for weapons. Since they are small enough to be easily air-transportable, they often support special operations. Examples are the Bell OH-58 Kiowa and the Boeing Sikorsky RAH-66 Comanche.

Power and Propulsion

The power plant, or engine, provides the power for the vehicle's drivetrain (p. 8-9) and electrical system. Two types of power plant are in common use on motor vehicles and helicopters: the internal combustion engine and the turbine.

Horsepower vs. Kilowatts

GURPS measures power using the kilowatt (kW), or 1,000 watts. "Horsepower" may be a more familiar measurement. One horsepower is equal to 0.746 kilowatts (or 0.736 kW for British horsepower). Thus, a 100-horsepower engine is 74.6 kW.

Internal Combustion Engines

These power plants burn fuel and air inside the engine. Internal combustion engines require oxygen at about Earth-normal pressure to work; thus, they do not function underwater, in vacuum, or in extraterrestrial atmospheres significantly lacking in oxygen. Subtypes include:

Gasoline Engines

The most common engines of the 20th and early 21st century. They burn a mixture of gasoline fuel and air. The expansion of the heated gases works a piston in a cylinder that drives a crankshaft, providing the rotary action needed to turn wheels, propellers, or the like. There are various types of gasoline engine, but the most common is the Otto cycle or four-stroke engine. It consists of one or more cylinders, each of which has intake and exhaust valves, an internal piston, and a spark plug. Four piston strokes (two up, two down) are required to produce power.

In the first "intake stroke," the piston moves down, creating a partial vacuum, the intake valve opens, and a mixture of fuel and air is forced into the cylinder. The engine's carburetor (in older engines) or a computerized fuel injection system (in newer engines) controls the mix of air and fuel.

The second "compression stroke" has the intake valve closed, trapping the fuel-air mixture, while the piston moves up to compress it. This prepares the fuel and air for ignition.

In the third "power stroke," an electric sparkplug in the cylinder head ignites the fuel and air in the combustion chamber. The violent expansion of the exhaust gases pushes the piston downward at full force, causing an attached crankshaft to turn, changing the up-down motion of the piston into a rotary motion that can turn the vehicle's wheels, running gear, or rotor.

The fourth "exhaust stroke" sees the exhaust valve open and the piston move up, forcing the spent exhaust gases from the cylinder. As the gas is evacuated the exhaust valve closes, the intake valve begins to open, and a new four-stroke cycle begins.

Small four-stroke engines, like those on lawnmowers, have one cylinder, but most automotive engines have four or more. Each cylinder will complete the combustion cycle at a different time to provide a smooth flow of power. The exact arrangement of the cylinders can vary depending on the exact engine design.

For example, a *V-engine* has a number of cylinders arranged at right angles in a V-shaped pattern to form the engine (e.g., a V-8 has eight cylinders); an *inline engine* has a single row of cylinders.

In addition to the Otto cycle four-stroke engines, other (less popular) automotive engines include two-stroke (used on small motor scooters), the Miller cycle (similar to four-stroke), and the light-weight Wankel rotary engine.

Diesel and Multi-Fuel Engines

Diesel engines are similar to gasoline engines, but have a different fuel ignition system. Where gasoline engines use an electric spark for ignition, diesel engines compress the fuel to ignite it. Diesel engines are generally heavier for a given power output than gasoline engines (and so are not used on helicopters or race cars), and tend to smoke. On the other hand, they use diesel fuel, which is cheaper and less flammable than gasoline. This makes diesel engines popular engine in large commercial vehicles, and for AFVs.

Multi-Fuel Engines are similar to diesels, but more versatile and more expensive. They can run on diesel, gasoline or jet fuel. They are commonly used in AFVs.

Turbochargers or Superchargers

These options are available for both gasoline and diesel engines. They increase power output for a given weight of engine by precompressing the air pulled into the engine. A *turbocharger* uses the exhaust stream to drive an air compressor, while a *supercharger* uses the drive shaft to do the same thing.

Sample Motive Powers

Here are some examples of motive powers and propulsion systems. Use these as guidelines when designing original vehicles:

Vehicle	*Engine's kW Rating*
Vespa ET4 motor scooter	8
Honda CB 500 light motorcycle	37
BMW R1100RT police motorcycle	67
2000 Volkswagen Beetle	86
Honda Accord EX sedan	112
M998 "Humvee" 4×4	112*
Kawasaki ZX-12R sports bike	134
Ford E-250 full-size van	142
Robinson R-44 Raven light copter	153
Dodge Intrepid police car	180
Bluebird TC2000 RE transit bus	186*
Ford Mustang sports coupe	186
M113A3 APC	205†*
BMW 7 luxury sedan	210
Shelby Cobra "muscle car"	250
Freightliner FLD120 semi tractor	298-350*
M2/3 Bradley IFV	448†*
Formula 1 race car	500-600
UH-1B "Huey" utility copter	1,044**
M1 Abrams tank	1,119†**
CH-47 Chinook heavy copter	2×2,798**

* Diesel engine. ** Turbine engine. † Tracked.

Gas Turbines

Gas turbines are derived from jet engine technology. They burn fuel and air, but the expanding gases spin a turbine blade rather than working a piston. This gives a simpler, smoother action and generally makes the power plant lighter for a given output. They are also quieter than a gasoline engine or diesel of the same power, with less smoke. Some turbines can also burn multiple fuel types, from jet fuel to gasoline.

The precision machining required for turbines makes them much more expensive than internal combustion engines, and they have a higher average fuel consumption. Even so, since the 1960s, turbines have been increasingly popular as helicopter engines due to their light weight. Some tanks also use them, but gas turbines are banned from most racing circuits.

Fuel

Power plants require fuel. The perfect fuel should be naturally abundant, cheap to refine, safe and easy to handle, and store lots of potential energy that can be easily released by the power plant. That doesn't exist, so compromises are made.

Gasoline is a flammable hydrocarbon petroleum distillate with a high thermal energy. Used in gasoline engines.

Diesel fuels are similar to gasoline, but cheaper to refine. They can only be used in special diesel or multi-fuel engines. They are less likely to catch fire than gasoline.

Jet fuel is high-grade kerosene, heavier, more expensive, and more flammable than gasoline.

Methanol (wood alcohol) fuel is used in racing vehicles. A specially designed methanol engine works like a gasoline engine. Methanol is only about half as fuel-efficient, and is somewhat toxic, but it's popular in racers because a methanol fire is much easier to put out than a gasoline fire: just use ordinary water.

Drivetrains

The drivetrain is the vehicle's transmission. It consists of the gears or turbines that convert the high-speed action of the engine's crankshaft or turboshaft into the reduced speed necessary to drive the movement of wheels, tracks, or rotors. Each type of motive system – rotors, tracks, wheels – on a powered vehicle has a corresponding drivetrain. Drivetrains require lubricating oil or transmission fluid to work smoothly, and are among one of the most maintenance-intensive parts of a vehicle.

Drivetrains on motor vehicles may be ordinary (front- or rear-wheel drive) systems that power one wheel on a motorcycle or one pair of wheels on other vehicles, or they may be heavier drive systems that transmit power to all axles (referred to as "four wheel drive" or 4×4 in a vehicle with four wheels). An all-wheel drive transmission system is better for off-road travel, since it ensures that at least some powered wheels are always in contact with the ground, even in very rough terrain.

The drivetrain and power plant together make up the "power train" of a vehicle.

Energy Banks

This is the generic ***GURPS*** term for energy storage cells of various sorts. In modern vehicles, these are batteries, and they're usually installed to provide electrical power for the vehicle's ignition system, and to provide energy for other systems such as radios and air-conditioning when the vehicle's main power plant isn't running.

Internal combustion engines use an electric ignition to provide the spark that ignites the fuel. They thus require a separate electrical battery. Civilian vehicles usually use an ignition key, while military vehicles typically have a starter knob. It takes about two seconds to start a gasoline engine, four seconds to start a diesel.

Two types of energy banks are in common use today:

Lead-Acid Batteries are basic chemical car, truck, and motorcycle batteries.

Advanced Batteries represent various alternative battery technologies that store the same amount of power for less weight, but which are more expensive.

Weaponry

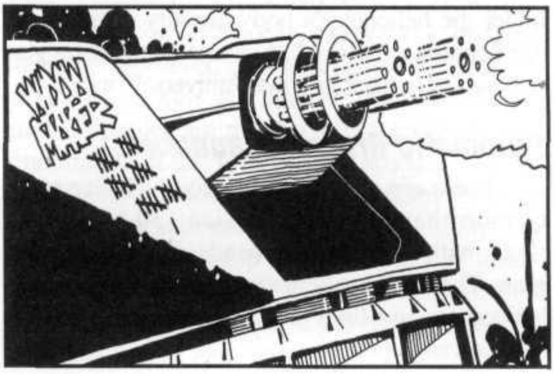
Modern fighting vehicles are armed with four basic types of weapon: guns, (unguided) rockets, (guided) missiles, and liquid projectors.

Guns

These weapons use the expanding gases from a chemical propellant to force a projectile down a barrel toward the target.

Guns are often defined by their bore size; e.g., 7.62mm or 105mm. This is the internal diameter of the gun barrel and thus the diameter in millimeters of the projectile it fires. For machine guns, the length of the bullet's cartridge is sometimes used as well; e.g., 7.62×51mm. Cannon are sometimes described with the length of the gun barrel, expressed in multiples of width ("calibers"). For example, a 100mm, 40-caliber gun has a barrel 40 times longer than its width, or 4,000mm long.

Guns firing projectiles with a bore size of 20mm or greater are sometimes referred to as "cannon" to distinguish them from "small arms" such as rifles and machine guns.



Machine Guns

These are vehicle-mounted versions of infantry weapons. They are capable of fully automatic fire (several bullets per second) and are fed by a continuous ammunition belt. The most common are the medium 7.62mm and heavy 12.7mm machine guns.

Tanks and IFV turrets often have a machine gun mounted *coaxial* to a larger autocannon or tank gun, which means it points in the same direction and is controlled by the same gunner. It's also common for military vehicles to put a machine gun on the body or turret roof, often on a post (a "pintle" or "open" mount), for anti-aircraft fire. Utility helicopters commonly mount 1 or 2 "door mounted" machine guns or a minigun just inside the cabin, where they can fire sideways out the aircraft's doors. Scout and attack helicopters sometimes put machine guns in pods on wing hardpoints.

Chain Guns: Most machine guns are gas- or recoil-operated, but some "chain guns" use an electric motor to drive their firing action. These are more reliable, but require a small power supply.

Miniguns: Similar to chain guns, but with 3-6 barrels. They use the Gatling principle: as each shot is fired, another barrel rotates in place and the next shot is fired through it. This keeps the barrels from overheating, allowing high rates of fire.

Autocannon

These are essentially large machine guns that fire cannon shells. Most autocannon are medium- or long-barreled weapons of 20 to 40mm bore. They are generally gas- or recoil-operated, but, as with machine guns, motor-driven chain guns are available, as are Gatling cannon (or "rotary cannon") which work like miniguns.

Turret-mounted autocannon or chain guns are the main armament of most Infantry Fighting Vehicles and combat reconnaissance vehicles. Attack helicopters often mount a single autocannon, chain gun, or Gatling gun in a limited-rotation forward-facing turret or open mount installed under the helicopter's body, usually at the nose. Air defense vehicles often mount one Gatling gun or a pair of autocannon in a "universal" turret.

Automatic Grenade Launchers

These are short-barreled, low-velocity autocannon that fire grenade-size (30 to 40mm) shells with explosive warheads. Some are chain guns. They are an alternative to machine guns for helicopters and light vehicles, with more punch but less range.

Tank Main Guns

The principal armament of tanks are large, high-velocity cannon mounted in rotating turrets. They typically fire shells weighing 20 to 50 lbs. Some combat reconnaissance vehicles and armored cars also have tank cannon. Low-pressure guns fire lower velocity shells.

76mm and 90mm Tank Guns: These weapons are typical of those used in late-WWII-era tanks. Today, these are mostly found on older light tanks and armored cars.

100mm and 105mm: These are characteristic of main battle tanks designed between the 1950s and the 1970s and modern light tanks, armored cars, and some IFVs.

120mm and 125mm: This size gun is characteristic of recent battle tanks.

Most modern guns use a grooved "rifled" barrel to spin projectiles, stabilizing them in flight for accuracy. However, standard modern tank-killing ammunition is fin-stabilized, and is simpler to design and somewhat more effective if fired from a smooth rather than a rifled barrel. Since smooth barrels are cheaper to make and less likely to wear out, some modern tanks use them instead of rifled tank guns.

Gun/Launchers: Since the 1970s, some tank cannon have been able to load and fire guided missiles as well as conventional gun ammunition. An AFV with a gun/launcher will often

carry half a dozen missiles as well as its ordinary ammunition. Gun/launcher capability involves adding various electronic components to the gun.

Gun and Missile Ammunition

The design of machine guns and cannon has changed little in the last 30 or 40 years, but their ammunition has become progressively more sophisticated. Machine guns usually just fire solid or AP bullets, but cannon have a wider range of choices. A few examples:

AP, Armor Piercing: These are specially hardened or shaped bullets or shells designed to penetrate armor. They do less damage than solid rounds against flesh.

API, Armor Piercing Incendiary: Identical to AP, except the round contains some incendiary material to improve the chance of starting a fire.

APDS, Armor Piercing Discarding Sabot: This sheaths a dense tungsten-core projectile in a light sabot ("say-bow"). When the shot leaves the barrel, the sabot falls away. The lighter sub-caliber penetrator flies on, with a higher velocity and flatter trajectory, making it better able to go through armor and giving it superior range.

APFSDS, Armor Piercing Fin Stabilized Discarding Sabot: This replaced APDS on many guns in the mid-1970s. Its penetrator is a "long rod" – a hardened tungsten dart 15-20 times as long as it is wide, with greater kinetic energy. The length of the penetrator means it must be fin-stabilized to avoid it tumbling in flight. This makes it slightly less effective when it is fired from conventional rifled guns, since a special mechanism has to be used to cancel its spin.

APFSDSDU, Armor-Piercing Fin Stabilized Discarding Sabot Depleted Uranium: Identical to APFSDS but using a penetrator manufactured out of depleted uranium. "DU" is spent fission reactor fuel, and very dense, giving it excellent armor-piercing capability. It also has an incendiary effect.

CHEM, Chemical: A round filled with smoke or gas.

HE, High Explosive: An explosive shell inside a casing designed to split into multiple sharp fragments. HE is effective against structures, light aircraft, or unarmored people and "soft-skinned" vehicles, but usually ineffective against AFVs.

HEAT, High-Explosive Anti-Tank: A specially constructed and shaped high explosive charge, which, when detonated moments before impact by means of a fuse or probe on the tip of the round, will explode in a way that transforms the metal liner of the round into a pencil-thin jet of molten metal traveling at many times the speed of sound. Its kinetic energy enables it to penetrate deep into armor, and it is the standard warhead for anti-tank rockets, missiles, and many cannon. Some late-model HEAT rounds are tandem-charge designs, using a pair of warheads to blow holes in reactive armor (p. 15) and enhance overall penetration.

HEAT-MP, HEAT-Multi-Purpose: A HEAT warhead with enhanced fragmentation (but reduced penetration). ***GURPS Vehicles*** calls this HEDP, but that term is reserved here for true HEDP rounds, which don't lose penetration.

HEDP, High Explosive Dual Purpose: This is a HEAT round with a heavy fragmenting case designed to combine the effect of HE and HEAT.

SAPHE, Semi-Armor Piercing High Explosive: A semi-armor piercing round is a HE warhead with a delay-impact fuse so it does not detonate immediately upon striking armor, instead penetrating and then exploding. This makes it much more effective against armor. Popular in autocannon.

Solid ("Ball") Ammunition: These are ordinary jacketed lead bullets.

The bigger the gun, the larger the projectile it fires, and hence the more damage will be done. Any AP-type, SAPHE, or solid ammunition is most effective when used by guns with longer barrels and greater chamber pressures, which allows them to fire shells at higher velocities, increasing their armor penetration and damaging ability. On the other hand, ammunition such as HE or HEAT has the same penetrating and damaging capabilities regardless of velocity, making it a good choice for lightweight, low-velocity weapons and missile warheads.

Launchers

Launchers fire self-propelled projectiles, such as unguided rockets or guided missiles. A launcher can be built much more lightly than an equivalent bore-size gun: It doesn't need strong, reinforced barrels or a recoil-countering mechanism. This means that small, light vehicles like helicopters or IFVs can carry tank-busting weapons! However, individual guided missiles or unguided rockets are heavier than shells, and guided missiles are more costly. As a result, less ammunition of this type can be carried.

Missile Launchers: These are tubes (or boxy containers) or rails mounted either on a firing post ("open mount") atop the vehicle, or "under armor" in a vehicle turret. Combat vehicles armed with missiles typically have 1-4 tubes, each with a missile loaded and ready to fire. Ground vehicles carry a few extra missiles as reloads.

Hardpoint Launchers: Attack helicopters usually have one to four hardpoints (on their body and under stub wings). Each hardpoint is usually rated for 200-500 lbs. of weaponry, typically one rocket pod or two or four identical guided missiles.

Rocket Pods are lightweight streamlined pods housing a half dozen or more 57mm to 80mm unguided rockets, often with HE or HEDP warheads. They can fire several at once, and while individual rockets are not very accurate, a salvo is devastating.

Gun/Launchers (p. 24) can also fire missiles, usually ATGM.

Guided Missiles

These are rockets with a guidance system that lets them be steered or home in on their target, dramatically improving their accuracy. Guided missiles include:

Anti-Tank Guided Missiles (ATGM): These are subsonic or supersonic missiles with a range of a few miles. They use HEAT warheads, and are designed to kill AFVs. They are also effective against buildings and unarmored vehicles, but are usually too slow to have much chance of hitting an agile helicopter or fast airplane.

SAM (Surface to Air Missile) or AAM (Air to Air Missile): Used to kill aircraft. They are usually supersonic, with a range of a few miles.

They typically have SAPHE or *Annular Blast Fragmentation (ABF)* warheads; the latter is a shaped proximity-fused explosive that projects blast and fragments in a lethal cone ahead of the projectile.

The following guidance systems are common:

Wire-Guided (WG): These are the usual ATGM guidance system, as they're simple and cheap. They are guided to the target by a human operator, using a wire that spools out behind the missile. In modern "SACLOS" systems, the gunner need only hold his sight on target. The launcher's control unit measures the deviation between the missile and the operator's line-of-sight, tracking an infrared source located in the tail of the missile. The control unit generates commands which are transmitted to the missile's guidance unit by the wire. In older "MCLOS" systems, the gunner actually steers the missile with a joystick. Since both are restricted by how fast the wire can spool, and how long it can be, these missiles are limited to speeds no greater than about 600 mph and ranges of about 4,000 yards. The other main limitation is that the gunner must guide the missile through its flight; and if he is killed, wounded, or otherwise distracted, it will crash.

Radio Command-Guided (RCG): This is similar to wire guidance, except that signals are sent to the missile by radio. It is slightly vulnerable to jamming and detection.

Infrared Homing (IRH): A "heat-seeking" sensor on the weapon homes in on infrared radiation. Early, "rear-aspect" IRH could only track very hot objects: exhaust pipes, fires, or (by accident) the sun. They are generally only effective against aircraft, and only when fired from behind where they can easily lock onto the super-hot metal of the engine exhaust pipes. Modern, "all-aspect" IRH weapons like Stinger use an improved sensor that can detect the warm metal of a vehicle's surface as well as the engine, enabling them to attack targets from any angle.

Semi-Active Laser Homing (SALH): Often called "laser-guided" or "laser-designated," the missile's seeker head homes in on the reflections of laser light that bounce off a target. Guiding the missile requires illuminating the target with a laser designator; this may be built into the firing vehicle, or external to it. Man-portable laser designators allow infantry to guide missiles for vehicles. Each designator transmits a particular coded signal, so missiles will home on the right target.

Armament Examples

AH-64 Apache (U.S. attack helicopter): 30mm light chain gun on open mount (limited rotation) under nose; two stub wings each with four hardpoints; usually carrying either a single 70mm 19-shot rocket pod or four Hellfire laser-guided missiles.

BMP-3 (Russian IFV): Turret with 100mmLP Gun/launcher, 30mm autocannon, and 7.62mm machine gun.

Leclerc (French MBT): Turret with 120mm long smoothbore and 12.7mm machine gun; open mount with 7.62mm machine gun.

Mi-24V "Hind E" (Russian assault helicopter): Turret with 12.7mm 4-barrel minigun; six hardpoints, three per stub wing, loaded symmetrically (i.e. with the same weapons on both sides). Usual armament for a single hardpoint is an 80mm 20-shot rocket pod or two AT-6 ATGMs.

M1 Abrams (U.S. MBT): Turret with 105mm rifled gun (M1) or 120mm smoothbore gun (M1A1) and 7.62×51mm machine gun; open mount (turret top) with 12.7mm machine gun.

M113 (U.S. APC): Open mount with 12.7mm machine gun.

M2/3 Bradley (U.S. IFV): Turret with two TOW ATGM launchers, 25mm chain gun, and 7.62mm machine gun.

Scorpion (British light tank): Turret with 76mm low-power gun and 7.62mm machine gun.

T-72, T-80, T-90 (Russian MBTs): Turret with 125mm gun/launcher and 7.62mm machine gun; open mount (turret top) with 12.7mm machine gun.

ZSU-23-4 Shilka (Russian self-propelled anti-aircraft gun): Turret with four 23mm autocannon and targeting radar.

Instruments and Electronics

In the 1940s and 50s, a vehicle was lucky if it had a radio or car stereo. Today, many vehicles are packed with electronic systems – even a passenger automobile may have computerized satellite GPS navigation and radar detector systems.

Communication Systems

Normal communicators are radios, sending signals by modulating the intensity, frequency. or phase of long-wavelength electromagnetic radiation.

Radios can send code, voice, text, video, or data transmissions, and, with the addition of computer terminals, text, video or data signals. Radios are omnidirectional broadcast systems, which means that anyone with a radio tuned to the proper frequency can listen in on a radio signal; radio transmissions can also be jammed.

Modern "scrambled" military radios like the U.S. Military's SINCGARS are channel-hopping, digital AM frequency units synchronized with other friendly radios by giving them a specific code. Once set to that code, they hop frequency in sync with other radios with the same code, changing channels every few seconds, so they cannot be locked onto and descrambled, even by a similar system. Anyone listening will only hear a series of high-pitched squeals.

Digital Datalink: This is a computer-controlled data management system that allows vehicles equipped with appropriate multifunction displays and digital radio communicators to perform real-time sharing of sensor, navigation, and targeting data, and to transfer text and graphic information, email messages, etc. An example is the U.S. Army's IVIS system installed in the M1A2 Abrams tank.

Navigation Systems

Knowing where you're going is of supreme importance, especially when crossing a trackless waste, traveling at night, or flying over water. In addition to traditional means such as a map and compass or radio beacon, vehicles may have:

Inertial Navigation System

This uses a gyrocompass (periodically updated by geomagnetic, GPS, or star-tracking techniques) to continuously fix the vehicle's position relative to known map coordinates, accurate to within 1' per 10 miles. INS systems are costly, but common in modern western MBTs, command vehicles, and self-propelled artillery, and in scout, attack, and special operations helicopters.

Global Positioning System (GPS)

These receivers use data from a constellation of two dozen orbiting GPS satellites to precisely determine the vehicle's location. Each satellite contains an atomic clock and a transmitter. The satellites' orbits are calculated so at least three of them will be over a location at any given time. By triangulating their transmissions, a GPS receiver can calculate location, altitude, speed, and course with great precision.

GPS receivers are lighter and cheaper than INS, but are reliant on the satellite transmissions and at the mercy of whoever controls them.

The main GPS system is the NAVSTAR system. The U.S. government originally selectively degraded NAVSTAR transmissions, in order to introduce errors (of 80-90 yards) for anyone lacking a military set with the proper codes. This was intended to prevent unfriendly forces' using GPS to guide bombs, missiles, or artillery strikes. Since May 1, 2000, the U.S. has unscrambled GPS transmissions, so even civilian sets are accurate down to 10-20 yards. However, it retains the ability to resume "selective availability" over a region should there be a need to do so.

Russia has a satellite navigation system, GLONASS, but it is underfunded and has only about two-thirds as many operating satellites as it requires, which occasionally results in "outages" due to gaps in satellite coverage. The European Union is developing its own system, Galileo, which is expected to be fully operational after 2008.

Sensors

Sensors allow a vehicle crew to detect things beyond the range of human vision, or to see in the dark. Most civilian vehicles lack any sensors, but almost all modern military vehicles possess them.

Low-Light TV (LLTV)

An electronic visual augmentation system consisting of telescopic optics and a light-amplifying night vision system, able to function in anything but total darkness. LLTV is often mounted on scout and reconnaissance helicopters, and on some AFVs. Most systems have 4× to 10× telescopic magnification.

Radar

Radar stands for "RAdio Detecting And Ranging." A radar set emits pulses of radio or microwave energy. These pulses are scattered back when they hit solid objects. The sensor collects and analyzes these reflections, measuring the time between the pulse and return in order to determine the object's position, range, and speed.

Radar is an active sensor – its beam can be detected by radar detector or locator systems at twice its actual range. Most modern radars are optimized for specific roles.

Fire control radars have precise ranging and target-tracking capabilities that can be used to aim weapons in lieu of visual sighting.

Most modern radars are optimized for a particular environment. Surface search (also called ground scan) radars are optimized for detecting targets on land or the water. Air search radars are optimized for detecting targets in the air. Some radars (usually modern pulse-doppler designs) can do both, but will be more expensive.

Radars are common on ships and airplanes, but rarer on ground vehicles and helicopters. Police cars may have small radars, although these are often hand-held devices designed specifically to measure speed. Radars are also coming into use on specialized reconnaissance AFVs and scout or gunship helicopters, but are by no means universal.

Infrared and Thermal Imaging

These are the most common sensors used by military ground vehicles and combat helicopters. They work in the infrared (IR) range, detecting the heat an object emits and comparing it to the background. Since an object is rarely the exact same temperature as its background, IR gives a good idea of an object's shape, although details of the same temperature (e.g., insignia painted on the side of a vehicle) are never visible.

Infrared sensors cannot see over the visual horizon, but they can penetrate darkness and normal smoke or fog. They can be blinded by very hot objects, such as flares or fires. They are also useful for spotting warm bodies or vehicles that are hiding in light cover, such as amid trees. Two types are in common use:

Infrared Searchlight: This is a large searchlight-like device that projects a beam of infrared light invisible to normal vision. It includes its own infrared image converter that makes objects illuminated by the IR light visible to the user, or anyone else with infrared searchlights or night vision goggles. This type of night vision gear has been around for the last half-century. By 2002, it is mostly found on obsolete or third-world military AFVs. The chief disadvantage is that the searchlight beam itself is highly visible to any infrared sensors, and only offers a fairly narrow field of view.

Thermal Imaging, Thermal Sight, Forward-Looking Infrared (FLIR): These three terms refer to the same thing: an advanced high-resolution infrared sensor. Thermal imaging devices use a cryogenically cooled heat sensor, which increases their sensitivity. They can measure the tiny differences in heat emitted by objects, digitally process this information, and convert it into a monochrome picture displayed on a TV screen. The resolution is sensitive enough to be able to see heat shapes concealed behind brush. These sensors are used by modern military vehicles, but are also coming into use for civilian craft such as police and search-and-rescue helicopters. ***GURPS*** uses the more generic term "thermograph" to refer to all thermal-imaging type sensors.

Data Management Systems

Multi-Function Displays (MFDs): Modern vehicles often have digital multi-function display screens in place of older and clumsier analog readouts and displays. These allow the user to page between displays that show things like navigation data, fluid status (fuel, oil, etc.), sensor readouts, weapons targeting information, and so on.

Integrated Digital Databus: Old vehicles with mechanical controls typically have numerous independent electronic and mechanical systems. A vehicle with this capability, such as the M1A2, uses a digital databus to links all subsystems together, allowing their status to be checked on MFDs and easing operator workload.

Targeting Systems

Ballistic Computers: These single-purpose computers perform ballistic calculations to correct a weapon's aim, accounting for variables such as wind, movement, elevation, ammunition type, wear on the barrel, and so on. The system includes sensors built into the vehicle to detect these variables. Modern MBTs and attack helicopters have ballistic computers, but other fighting vehicles may not. ***GURPS Vehicles*** refers to this system as a "dedicated targeting computer."

Rangefinders: When projectiles are fired at long ranges, a gunner cannot aim directly at the target: The gun has to elevate a bit in order to compensate for the natural fall of the projectile and curve of the horizon. All vehicle-mounted weapons are assumed to have an ordinary coincidence or stereoscopic optical rangefinder which provides an approximate range calculation. However, since the 1970s, laser rangefinders have come into use. These use a laser beam to calculate range precisely. The disadvantage of a laser rangefinder is that vehicles can have laser sensors that warn the target when it is being "lased."

Thermal Sights: Many modern fighting vehicles use infrared "thermal sights" – these are simply thermal imaging systems (see above) that the gunner can use. (In ***GURPS Vehicles*** terms, they're a thermograph sensor that is assigned to the gunner's crew station.)

Laser Designator: This device is designed to illuminate ("paint") a target with an invisible, infrared laser beam. The beam is modulated with a unique code, which laser-guided missiles and bombs can sense and home in on (see *Semi-Active Laser Homing,* p. 12). Laser target designators are typically built into scout and attack helicopters, as well as specialized reconnaissance and artillery fire-direction vehicles.

Heads-Up Display Weapon Aiming Computer (HUDWAC): This is a device that is usually only found on attack and scout helicopters. It ties the vehicle's weapons systems into an integrated Heads-Up Display which projects useful information directly in front of the crew member's eyes, either on the windshield or onto a helmet-mounted eyepiece display, making it easier to aim weapons quickly.

Helmet-Mounted Sight: This is a helmet-mounted device slaved to the user's movement. It trains any movable (e.g., turret-mounted) weapons and sensors wherever the user looks, helping him aim and fire quickly. ***GURPS Vehicles*** refers to this as a HUDWAC with pupil-scanner.

Hunter-Killer Sights: Some modern MBTs have what is called a "hunter-killer" sight. This is a set of panoramic thermal imaging sensors linked to multifunction displays and duplicate gun controls to enable that tank's gunner and tank commander to hunt cooperatively for one target while firing at a different one. In game terms, a vehicle has this capability if it possesses individual computer terminals for the gunner and commander, along with two turret-mounted thermographs.

Mast-Mounted Sight: This is a set of sensors and targeting systems mounted atop a scout or attack helicopter's main rotor, so it can spot targets while remaining partly concealed behind hills or buildings. A MMS usually includes a laser designator, low-light TV, and thermal imaging. Some systems, such as Apache Longbow, add a radar.

Armor and Defenses

Most vehicles have some form of "armor" – even if it's only the thin aluminum or steel that forms an automobile's body, or the roll cage of a race car. But some vehicles, such as tanks and attack helicopters, are deliberately designed to resist enemy fire.

Metal

Metal is the most common armor material. Metals in use include cast or welded steel, aluminum alloy, and various steel alloys. The standard vehicular armor plate is a high-grade steel alloy known as rolled homogeneous armor (RHA).

Composites

Composite materials include fiberglass, rigid, resin-bonded Kevlar, high-density ceramic plates, and carbon-aluminum composites. They are as strong as steel, but lighter and more expensive. This type of armor is usually used where weight is more important than cost; it is often found on armored limousines and off-road vehicles, and on helicopters and racing vehicles.

Laminate

Laminate armor is more resistant to damage for a given weight, and is especially effective against the explosive shaped-charge ammunition commonly used in the warheads of rocket-propelled grenades and other anti-tank rockets and missiles. An example of laminate is "Chobham" armor used on modern Western tanks. Chobham armor is a sandwich of outer and inner hard steel plates containing layers of ceramic blocks held within a special resin. This is sometimes reinforced with a metallic mesh made of dense depleted uranium. The exact makeup of this armor is highly classified.

Russian and Israeli tanks also use their own versions of laminate armor. Russian "sandwich" laminate armor is a composite of aluminum-plastic-steel, and is somewhat less effective than Chobham armor, but cheaper to manufacture.

Sloped Armor

Armor on AFV bodies and turrets is often sloped to deflect attacks. It is common for AFVs to have a 30- to 60-degree slope on their front body and front turret. Sometimes the sides and rear of a turret or rear body are sloped as well.

Explosive Reactive Armor (ERA)

Explosive reactive armor is a special type of armor that can be applied to an AFV over its regular armor. Individual reactive armor plates (RAP) are cinderblock-sized explosive tiles intended to protect against the deadly shaped-charge (HEAT or HEDP) ammunition used by many cannon and missile warheads.

As a shaped-charge warhead hits a RAP, the explosive in the RAP detonates. This blasts the metal plate forward, disrupting the formation of the jet of molten metal on which the shaped-charge warhead relies for penetration.

Real-World Armor Values and DR

AFV reference works often describe vehicular armor as offering protection equivalent to a given thickness in millimeters of RHA, whether or not the armor is actually that thick. Often it is sloped, or made of laminate, which means its actual thickness is different. To convert this into DR, multiply thickness (in mm) by 2.8.

Spall Liners

When a projectile smashes into a vehicle, it often causes chunks of armor to break off and scatter fragments through the vehicle's interior, sometimes causing more damage than the projectile itself. This is known as spalling. To counter it, some recent vehicle designs have been fitted or retrofitted with spall liners made of Kevlar or ballistic nylon, fitted to the interior of the body or turret. Spall liners have been credited with reducing casualties from penetrating hits by as much as 50%.

Other Protective Systems

"Crash-proof" or self-sealing fuel tanks are common on both racing and fighting vehicles. So are semi-automatic fire extinguishers or automatic fire suppression systems that flood a vehicle with inert halon gas, putting fires out almost instantly.

Nuclear-Biological-Chemical Defenses

The risk of attack by chemical or biological agents (and nuclear fallout, in a total war) has led to many modern AFVs being equipped with specialized "NBC" (Nuclear-Biological-Chemical) protective equipment.

An "NBC kit" defends against nuclear fallout, germs, or chemicals such as pollution or poison gas. Only people entirely inside the vehicle benefit from an NBC kit, and the vehicle must be sealed. A typical NBC kit consists of sensors to detect contaminants, filters, and an overpressure system that keeps the vehicle's interior at higher air pressure than outside, to keep impure air out. Some older systems have individual masks for occupants, connected to a supply of clean air.

Countermeasures

The best defense is to avoid being detected – or if that can't be helped, to avoid being hit. This class of devices (abbreviated ECM) is used to detect, locate, jam, or confuse electronic emissions such as radio or radar, and to confuse incoming guided missiles. While countermeasures are mainly military devices, ECM systems are carried by civilian vehicles in some jurisdictions – the ubiquitous radar detector is a good example. Examples of countermeasures are:

Radar Detector: This device alerts the crew if it is within range of an operating radar. Radar detectors have recently become available for automobiles, to detect police radar. These are illegal in some areas.

Laser Sensor: This warns the crew when a laser beam (from a laser rangefinder or laser designator, for example) is pointed at the vehicle. With the proliferation of laser-guided weapons, these are now standard equipment.

Radar Warning Receiver (RWR): A military version of the radar detector. It differs from civilian models in being able to determine the nature of a threat ("fire control radar has locked on") and the direction it originates from. ***GURPS Vehicles*** calls this an "advanced radar detector." Most RWR will distinguish between radars being used to target weapons and radars that are simply searching the area.

Smoke Grenade Dischargers: Tanks are usually equipped with turret-mounted multi-barrel grenade launchers designed to fire a salvo of smoke grenades in front of the turret to create an instant dense smoke screen. Smoke can be conventional smoke, or "hot smoke" containing hot metal particles that also blocks infrared sensors. Some Russian vehicles have deployed a system called *Shtora,* that uses laser sensors and special anti-laser prismatic ("prism") smoke grenades to block laser designators and rangefinders.

Infrared Jammer: Usually deployed on helicopters, this is typically an electrically heated "brick" in the tail boom that is designed to confuse or overload the seeker heads on infrared-homing missiles. An example is the U.S. ALQ-144 "disco ball."

Flare Dischargers: These are boxes that launch hot flares designed to decoy incoming infrared-homing missiles. They are usually mounted on combat helicopters. Flares have limited effectiveness against the most recent generation of imaging infrared homing missiles, which can tell the difference between a flare and a target.

Smoke Screen Generator: Some vehicles with diesel engines have the capability to inject raw diesel oil into their exhaust, creating a smoke screen behind the vehicle. This is not as useful as a smoke grenade discharger, but can be helpful if retreating.

Vehicle Design 2

This chapter provides a comprehensive meta-system for creating modern ground vehicles and helicopters. Use scratch paper (or a simple spreadsheet) to keep track of the vehicle's characteristics as they are designed. Afterwards, record the necessary essentials of the finished design as per the sample vehicle format on pp. 60-64.

Concept

First, come up with a general concept of the vehicle. Decide if you want to make up your own vehicle, or attempt to reproduce some or all of the characteristics of a real vehicle. What's it for? What should it look like? Examples of concepts are provided in Chapter 1 and Chapter 5.

The Design Process

A vehicle is designed by choosing the major *subassemblies* (like wheels, rotors, or turrets), along with any *body features* like streamlining. This determines its shape. The major part of vehicle design is the selection (and in some cases, design) of various components, like engines or seats, and their placement within the body or subassemblies. Then the volume of the body and each subassembly is determined, and the size, weight, and cost of the structure and any armor are calculated. (Alternatively, this can be done before choosing the components, with components selected to fill the "empty" body and subassembly spaces). Last of all, the vehicle's statistics are determined. If it's a made-up vehicle, it can be given a name. If it's a real vehicle, you may wish to tweak any statistics for which you possess complete data, so that it more precisely matches its real-world equivalent.

Tech Level

GURPS Vehicles Lite is intended for TL7 vehicles, those designed and built with technology equivalent to that used in the Earth period 1950-2000. Since it often takes several years to go from concept to production, this actually means that "real world" designs from the late 1950s to the first decade of the 21st century are the best match for "TL7 designs." Unless otherwise noted, assume all components are TL7. In a few cases, early TL8 components have been made available (as "improved" systems) for increased cost. The terms "early TL7" and "late TL7" differentiate between the items available in the first or second half of the period, notably vehicle electronics.

Subassemblies

Every vehicle has a main *body*. But many vehicles have subassemblies attached to their body, such as wheels, wings, or turrets.

Motive Subassemblies

First, pick *one* motive subassembly for the vehicle; this also includes not only the actual wheels, tracks, or skids, but also the suspension, brakes, and steering:

Small Wheels: Used on helicopters, as landing gear.

Skids: An alternative to small wheels for helicopter landing gear.

Pontoons: Skids alternative for water landing.

Standard Wheels: Used by most cars, vans, trailers, SUVs, and cycles.

Heavy Wheels: Used by many oversized vehicles, like trucks and tractor-trailers.

Off-Road Wheels: Used on all-terrain vehicles, dirt bikes, and wheeled AFVs.

Tracks: Used on caterpillar tracked vehicles, like bulldozers or tanks.

A single subassembly represents *all* wheels, skids, tracks, etc. on the vehicle. Vehicles with skids or tracks are assumed to have two tracks or two skids. In the case of wheels, choose the number of wheel positions: one, two, three, or any even number.

Flight Subassemblies

To create a helicopter, also select *one* of these rotor types:

Top-and-Tail Rotor (TTR): One large top rotor and one small tail rotor, plus a tail.

Multiple Main Rotor (MMR): Two large rotors, a system used mostly on larger helicopters.

Coaxial Rotors (CAR): Two top rotors rotating in opposite directions, or other no-tail-rotor systems, plus a tail.

In the case of MMR, *each* rotor is a distinct subassembly. Otherwise, treat both top and tail rotor or both coaxial rotors as a single distinct subassembly.

Stub Wing Subassemblies

A helicopter may *optionally* be given two stub wings, to which weapons hardpoints can be attached. Each stub wing is a distinct subassembly.

Turret Subassemblies

Any vehicle may optionally have a powered rotating turret. A turret can house various components, often weapons or sensors, and the crew that operate them.

Limited-Rotation Turret: A turret with up to 180° rotation, like a chin turret under the nose of a helicopter gunship; assumed to face forward unless noted.

Full-Rotation Turret: A turret with 360° rotation, like one atop a tank's body.

Open Mount Subassemblies

These are brackets, pedestals, or masts used to mount equipment – usually sensors or weapons – *outside* the vehicle's structure. Open mounts must be bought as fixed, limited rotation, or full rotation. Any component that could go in a turret may be installed in an open mount; an open mount may also be left "empty" for later use.

Body Features

At this stage, decide if the vehicle has slope and/or streamlining. Both are optional.

Streamlining

Streamlining is common on aircraft and racing vehicles. Decide if the vehicle is streamlined, and if so, to what degree. Streamlining adds cost and overall volume, but reduces aerodynamic drag, increasing speed.

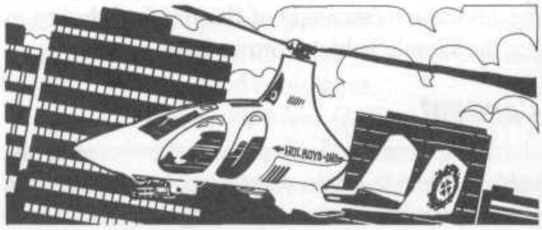
Fair Streamlining: Sleek body style typical of sports cars and many helicopters.

Good Streamlining: Typical of racing cars and a few fast helicopters. On ground vehicles, it includes winglets that generate downforce to keep the vehicle on the road.

Slope

Will the vehicle's body and/or turret have sloped armor, like many modern AFVs? A sloped body or turret is larger (there's less usable internal space) but improves the effectiveness of armor. The right, left, front, or back faces of the body, and of a turret, can be given either no slope, a 30° slope, or a 60° slope. Decide what faces are sloped, and how much, if any, they have. This can differ between body and turret. It's most common for AFVs to have 30° to 60° slope on front body and, sometimes, on the front turret.

To represent a *rounded* turret, like those on many Russian tanks, give the turret 30° slope on its *top* but not on other faces. Otherwise, top slope is not allowed.



Design Paths

Now that the vehicle's general configuration has been determined, there are two ways to proceed:

Components-First Design Path

Design the vehicle's internal *components* first, then build the body (and turret) to enclose them. Go to *Components*, p. 19. Select a set of propulsion, weaponry, instruments and electronics, miscellaneous, crew and passengers, power and fuel, and cargo components. They can go in the body, turrets, or open mounts; note where they fit.

After all the components are selected, proceed to *Volume and Structure*, p. 31.

Structure-First Design Path

Design the vehicle's *structure* first, then fill the body and any open mounts or turrets with components. To do this, simply assign cubic feet of *empty space* to the body, based on how much internal space seems reasonable (see below for a guide). Then do the same for turrets and open mounts. Skip the *Components* section below, and instead proceed to *Volume and Structure,* p. 31, and calculate the vehicle volume, area, structural and armor statistics based on the chosen empty space. Then go back to *Components* (p. 19) and replace the empty space with the desired vehicle components and cargo space. Make sure that the chosen components do not exceed the empty space allotted for them!

Coaxial Rotors (CAR): Two top rotors rotating in opposite directions, or other no-tail-rotor systems, plus a tail.

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These are brackets, pedestals, or masts used to mount equipment – usually sensors or weapons – *outside* the vehicle's structure. Open mounts must be bought as fixed, limited rotation, or full rotation. Any component that could go in a turret may be installed in an open mount; an open mount may also be left "empty" for later use.

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At this stage, decide if the vehicle has slope and/or streamlining. Both are optional.

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Streamlining is common on aircraft and racing vehicles. Decide if the vehicle is streamlined, and if so, to what degree. Streamlining adds cost and overall volume, but reduces aerodynamic drag, increasing speed.

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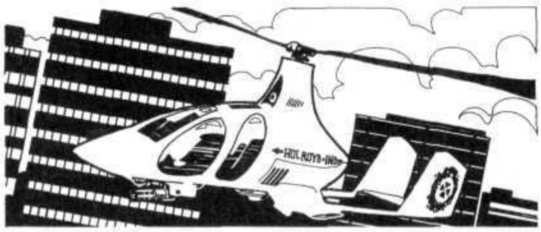

Design Paths

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Components-First Design Path

Design the vehicle's internal *components* first, then build the body (and turret) to enclose them. Go to *Components*, p. 19. Select a set of propulsion, weaponry, instruments and electronics, miscellaneous, crew and passengers, power and fuel, and cargo components. They can go in the body, turrets, or open mounts; note where they fit.

After all the components are selected, proceed to *Volume and Structure*, p. 31.

Structure-First Design Path

Design the vehicle's *structure* first, then fill the body and any open mounts or turrets with components. To do this, simply assign cubic feet of *empty space* to the body, based on how much internal space seems reasonable (see below for a guide). Then do the same for turrets and open mounts. Skip the *Components* section below, and instead proceed to *Volume and Structure,* p. 31, and calculate the vehicle volume, area, structural and armor statistics based on the chosen empty space. Then go back to *Components* (p. 19) and replace the empty space with the desired vehicle components and cargo space. Make sure that the chosen components do not exceed the empty space allotted for them!

Empty Space for Structure-First Designs

If using the structure-first design path, selecting the empty space for the body and any turrets or open mounts is important. If trying to duplicate a real vehicle, it can be roughly estimated from any known dimensions. Otherwise, suggested empty space values are:

Vehicle	*Empty Space in Body*
Motorcycles	7-15 cf
ATVs, Dune buggies	30-70 cf
Open-top autos or 4×4 vehicles	80-125 cf
Coupes, light helicopters	125-150 cf
Most sedans	160-250 cf
Sport utility vehicles	250-400 cf
Medium-lift helicopters, vans, semi-tractors	300-400 cf
Most AFVs	300-600 cf
Heavy lift helicopters, buses, motor homes	750-1,500 cf
Large semi-trailers	1,600-2,500 cf

Turrets will usually be about 20% to 50% of the size of a body. The most common *open mount* is a pintle for a machine gun or similar weapon, which is about 2 cf.

Components

These are the parts built *into* the vehicle. They include things like drivetrains, engines, weapons, seats, fuel tanks, and cargo. Most of the design process consists of selecting the vehicle's components, determining their characteristics, and deciding where to put them.

Each component has several statistics. The first is its basic description, e.g., "standard gasoline engine, 200 kW output." The other statistics are:

Weight (wt.) measured in pounds (lbs.).

Cost is in dollars.

Volume measured in cubic feet (cf). If the component is to be placed in a turret or open mount, note this by recording a T or O next to it; if it has multiple open mounts, use O1 for the first, O2 for the second, etc.

Power requirement in kilowatts. Some components require "negligible" (abbreviated "neg.") amounts of power. They function as long as the vehicle has any kind of working power system. At the GM's option, a negligible power component draws 0.01 kW power.

Choosing Components

Go through the design sequence below, starting with *Drivetrains*, to choose what the vehicle needs. Use the background information in Chapter 1 and the sample vehicles in Chapter 5 as guidelines.

When a component is chosen, record its description and work out its statistics, and keep running totals of weight, cost, volume (in each location), and power required.

If body (or turret) component volumes have been specified, take care not to select components for which their combined volume exceeds the available space.

Drivetrains

Vehicles other than trailers will have a drivetrain as their propulsion system.

Motive Power and Propulsion

Motive power is a measure of how much power the vehicle can devote to a given propulsion system. It's rated in kilowatts (kW). 1 horsepower is roughly 0.75 kW. The greater the motive power relative to the vehicle's weight, the more agile it will be.

See *Sample Motive Powers* on p. 8 for real-world examples. In most cases, a vehicle's motive power and engine power output will be the same.

Drivetrain Types

These are transmissions or electric motors that convert power into movement of wheels, tracks or rotors. "Improved" designs are late TL7/early TL8 designs.

Wheeled or All-Wheel Drivetrain: A self-propelled vehicle with standard, heavy, or off-road wheels needs one or the other. All-wheel drive is heavier, but improves off-road speed. All-wheel drive *does not* require off-road wheels.

Tracked Drivetrain: A vehicle with a tracked subassembly must have this kind of drivetrain to transfer power to the running gear.

Helicopter Drivetrain: This is needed if the vehicle has helicopter rotors. A vehicle with a top-and-tail rotor (TTR) or coaxial rotor (CAR) arrangement requires one drivetrain. One with multiple main rotors (MMR) configuration requires two drivetrains, each with the same motive power (they add together). Helicopter drivetrains must match the rotor type, e.g., a vehicle with TTR rotors requires a TTR drivetrain.

Drivetrain Table

Type	*Weight in lbs. when Motive Power is:* *under 5 kW*	*5 kW or more*	*Cost*
Wheeled	7.5 × kW	(1.5 × kW) + 30	$10
Improved Wheeled	5 × kW	(1 × kW) + 20	$20
Wheeled All-Wheel-Drive	10 × kW	(2 × kW) + 40	$20
Improved All-Wheel-Drive	7.5 × kW	(1.5 × kW) + 30	$40
Tracked	20 × kW	(4 × kW) + 80	$20
Improved Tracked	15 × kW	(3 × kW) + 60	$40
CAR Rotor Drivetrain	6 × kW	(0.6 × kW) + 27	$50
Improved CAR Rotor Drivetrain	4 × kW	(0.4 × kW) + 18	$100
TTR or MMR Rotor Drivetrain	5.5 × kW	(0.5 × kW) + 25	$25
Improved TTR or MMR Rotor Drivetrain	3.3 × kW	(0.3 × kW) + 15	$50

Work out the drivetrain's weight, volume, cost and power requirement using the table above:

Weight: The weight as a function of motive power is shown on the table above.

Cost: The cost of drivetrains is based on their weight multiplied by the number shown in the cost column on the table.

Volume: The volume is (modified weight/25) cf, including access space. Drivetrains must go in the body of a vehicle.

Power Requirement: This is equal to the motive power.

For example, suppose we select a 100-kW improved wheeled drivetrain. It weighs (1 × 100) + 20 lbs., or 120 lbs. It takes up 120/25 = 4.8 cf in the body. It costs 120 × $20 = $2,400.

Water Drive: Some amphibious land vehicles have small external auxiliary screw propellers or hydrojets for water operations, connected to the drive shaft. A water drive adds 10% to the weight and volume of a connected wheeled or tracked drivetrain. It costs $10 per pound. Motive power of the water drive is weight-20.

Helicopter Lift

If the vehicle has helicopter rotors and drivetrains, motive power sets the rotor's helicopter lift – the maximum weight it can carry and still fly. It is 10 lbs. × motive power for TTR or CAR rotors, 12 lbs. × combined motive power for MMR rotors. Keep a running total of component and other weights, to ensure that the final helicopter design can lift itself!

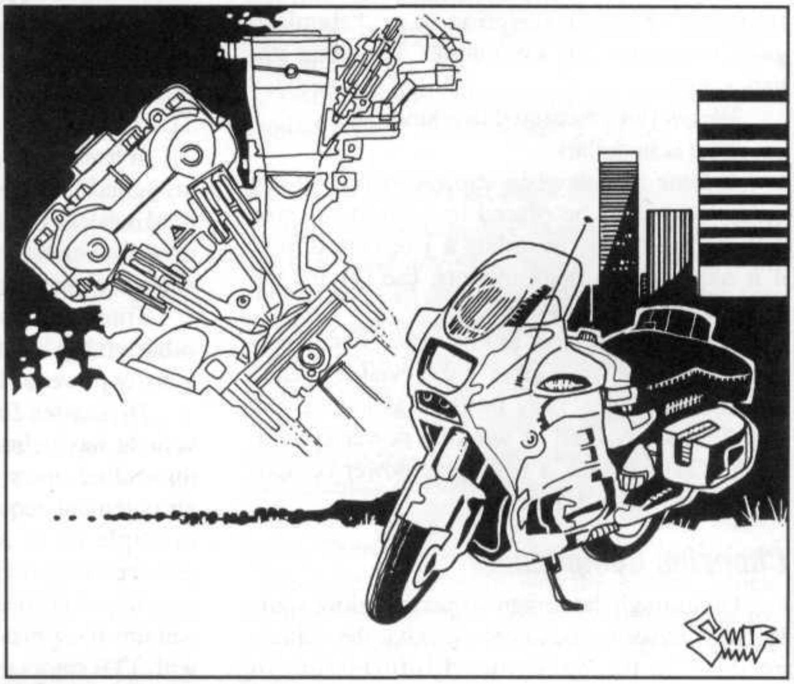
Power Plant

A vehicle needs a power plant to meet power requirements of other components. To design a power plant, choose a type from the *Power Plant Table* and select its output in kW. The output normally will equal drivetrain motive power. If desired, some excess output can be taken to power other systems, but on almost all ground vehicles and helicopters, this can be ignored; instead, give the vehicle an energy bank (p. 30) to power other systems when the engine is being run at full power.

Multiple power plants are possible, e.g., a twin-engine helicopter; add output together.

Various types of power plants are available. The choice comes down to selecting the best trade-off between weight/volume (the lower the weight per kW, the better), cost (the cheaper, the better), and fuel economy (the less fuel burned, the better).

"Racing" engines are highly tuned designs that require constant maintenance; they are assumed to be turbo- or supercharged.



Power Plant Table

Type	*Weight if output is under 5kW*	*5kW or more*	*Cost*	*Fuel*
Internal Combustion Engines				
Std. Gasoline	10 × kW	(5 × kW) + 25	$5	0.04G
if turbo- or supercharged	8 × kW	(4 × kW) + 20	$10	0.04G
Imp. Std. Gasoline	8 × kW	(4 × kW) + 20	$8	0.035G
if turbo- or supercharged	6 × kW	(3 × kW) + 15	$15	0.035G
HP Gasoline	5 × kW	(2.5 × kW)+12.5	$20	0.045G
if turbo- or supercharged	4.25 × kW	(2.25 × kW) + 10	$40	0.045G
Imp. HP Gasoline	2.5 × kW	(1.5 × kW) + 5	$40	0.04G
if turbo- or supercharged	2 × kW	(1.25 × kW) +5	$80	0.04G
Std. Diesel	14 × kW	(8 × kW) + 30	$4	0.035D
if turbocharged	12 × kW	(6 × kW) + 30	$6	0.035D
HP Diesel	8 × kW	(4 × kW) + 20	$10	0.04D
if turbocharged	6 × kW	(3 × kW) + 15	$20	0.04D
Imp. Diesel	8 × kW	(4 × kW) + 20	$20	0.035D
if turbocharged	6 × kW	(3 × kW) + 15	$40	0.035D
Racing Gasoline Engine	2 × kW	(1 × kW) + 5	$100	0.055G
Imp. Racing Gasoline Engine	1.75 × kW	(0.75 × kW) + 5	$150	0.05G
Gas Turbines				
Optimized Gas Turbine	15 × kW	(3 × kW) + 60	$20	0.05M
Std. Gas Turbine	10 × kW	(2 × kW) + 40	$20	0.06M
HP Gas Turbine	4 × kW	(1 × kW) + 15	$50	0.07J
Imp. HP Gas Turbine	2.5 × kW	(0.5 × kW) + 10	$80	0.06J

Weight: Calculate the weight of the power plant as shown on the table above, based on output. Note that there are two columns – one for power plants with outputs under 5 kW, the other for larger power plants.

Cost: This is the cost per pound of power plant weight.

Volume: Divide weight by 25 to find volume in cf (including access space). Power plants go in the body of the vehicle.

Fuel: This is the fuel consumption in gallons per hour (gph) of fuel per kW of output. If a multi-fuel engine is running on alcohol multiply the gph by 1.2.

Abbreviations: Imp. = improved; Std. = standard; HP = high power; G = gasoline, D = diesel oil, M = multi-fuel (may use gasoline, diesel or alcohol), J = jet fuel.

Fuel

Any power plant that has a rated fuel consumption requires fuel tanks and fuel.

Fuel Tanks

If a power plant is not provided with fuel, it will not function. Fuel tanks may also be light (saves weight, but more costly) and/or self-sealing (which don't leak if damaged).

To install a tank, decide on its type, capacity in gallons, and the kind of fuel it holds. A good way to select the capacity is to multiply the gallons per hour of fuel the power plant or engine consumes by the desired number of hours of endurance between refueling – typically 1 to 2 hours for helicopters, 2 to 12 hours for ground vehicles.

The table below gives values for the cost, weight, and volume of the fuel tank per gallon of fuel. The "fire" column is the modifier to the chance of the fuel catching fire if damaged.

Fuel Tank Table

Type	*Weight*	*Vol.*	*Cost*	*Fire*
Standard	1	0.15	$5	0
Standard Self-Sealing	2	0.15	$10	-1
Light	0.5	0.15	$10	+1
Light Self-Sealing	1	0.15	$20	0

Weight, volume, and cost are per gallon. The actual weight of the fuel itself is not included. Fuel tanks can go in the body or turrets.

Fire: Some fuel types have a "Fire" number. The type of tank will modify that number as shown above.

After the fuel tank is installed, refer to the table below to find out how much a full tank of fuel weighs and costs per gallon. This increases the vehicle's loaded weight, but not empty weight.

Fuel Table

Fuel	*Weight*	*Cost*	*Fire*
Aviation Gas	6.5	$2	13
Diesel	6	$1.2	9
Gasoline	6	$1.5	11
Jet Fuel	6.5	$3	13

Weight is per gallon of fuel or reaction mass.

Cost is the cost per gallon of fuel. However, this may vary considerably by region.

Fire: Some fuel types have a "Fire" number. This is the chance or less on 3d that the fuel will catch fire when damaged (see Chapter 4, *Combat*).

Power Plant and Drivetrain Options

Blueprinted: Any power plant and drivetrain can be "blueprinted," or rebuilt and finely tuned by a skilled mechanic to achieve higher than stock performance, to a maximum of +10% to motive power or output. Each +1% added to motive power (drivetrain) or output (power plant) adds 10% to cost, and, for power plants, 1% to fuel consumption.

Methanol Engines: Gasoline engines can be built to run on alcohol (methanol) fuel instead. Double fuel consumption (gph).

Multi-Fuel Diesels: A *multi-fuel* engine that can run on gasoline, diesel, and jet fuel is available. Use the same statistics for diesel engines, but add 20% to cost. When the engine is running on gasoline or jet fuel, multiply the gph by 1.2.

Built-in Weaponry

Vehicles can be armed with a wide variety of built-in ranged weapons. This section presents a selection of AFV and helicopter weapon systems. Generic names have been given for guns, so the weapons can "stand in" for a wide range of different models, many of which are almost identical. The closest real counterpart is also listed.

Only permanent or semi-permanent weapon installations built into the body or subassemblies are selected at this stage in the design process. Weapons that would be added on external pylons ("hardpoints"), such as most helicopter-mounted rocket and missile launchers, are not installed at this point; skip any such weapons for now.

The *Weapon Installation Tables* (below) give weight, volume, cost, and power statistics for weapons and ammunition. For combat statistics, refer to the *Weapon Tables* on pp. 57-59. As a single gunner can only fire one weapon (or one set of linked weapons, see *Links*, p. 24) at a time, most armed vehicles have only one to four distinct weapons.

Facing: For a weapon located in the body or any other subassembly, specify whether it points forward (F), backward (B), right (R), left (L), or in rare cases, up (U) or down (D); this is the direction it can fire. Of course, a weapon in a turret or rotating open mount can fire in different directions as it rotates. A weapon can't be mounted fire through the vehicle – for example, a gun in a turret atop a vehicle can't face down.

Weight, Volume, Cost: This is for the unloaded weapon. A weapon can be concealed: if so, multiply volume by 2.5.

WPS, VPS, CPS: This is the volume, weight, and cost of one round of ammunition: bullet, shell, or missile. If two WPS values are given, e.g. 43/51, the smaller is for APFSDS or APFSDSDU ammo; the larger applies to other types. Missile launchers, unlike guns, carry a loaded round; VPS is for second and subsequent missiles.

Ldr: Some weapons require a crew member person to load manually after each shot. If the gunner must also load, the RoF is halved (e.g., 1/2 becomes 1/4).

Missile Installation Table

Anti-Tank Guided Missiles

Weapon	*Weight*	*Volume*	*Cost*	*Power*	*WPS*	*VPS*	*CPS*	*TL*
120mm WG ATGM (AT-4 Spigot-B; RU)	60	1.2	$30,000	neg.	29	0.58	$15,000	7
125mm old WG ATGM (AT-3a Sagger; RU)	50	1	$10,000	neg.	25	0.5	$5,000	7
125mm SACLOS ATGM (MILAN-2; EU)	52	1.1	$20,000	neg.	26	0.52	$10,000	7
130mm RG SACLOS (AT-6a Spiral; RU)	140	2.8	$50,000	neg.	70	1.4	$25,000	7
130mm SALH (AT-9 Ataka; RU)	180	3.6	$90,000	neg.	90	1.8	$45,000*	7
135mm SACLOS ATGM (AT-5 Spandrel; RU)	110	2.2	$18,000	neg.	55	1.1	$9,000	7
152mm SACLOS ATGM (TOW-2A; US)	125	2.5	$20,000	neg.	50	1	$10,000	7
165mm SACLOS ATGM (HOT-3; EU)	145	2.9	$70,000	neg.	72	1.4	$35,000	7
178mm SALH ATGM (AGM-114C Hellfire; US)	200	4	$200,000	neg.	100	2	$100,000	7

IR-Homing Anti-Aircraft Missiles

Weapon	*Weight*	*Volume*	*Cost*	*Power*	*WPS*	*VPS*	*CPS*	*TL*
70mm IRH-AAM (FIM-92 Stinger; US)	44	0.9	$76,000	neg.	22	0.4	$38,000	7
90mm IRH-AAM (Mistral; FR)	80	1.6	$120,000	neg.	40	0.8	$60,000	7
120mm IRH-AAM (SA-13 Gopher; RU)	180	3.6	$90,000	neg.	90	1.8	$45,000	7

Most missile-armed ground vehicles have one or two launchers, with a half-dozen or so reloads. Helicopters usually install missiles on hardpoints (p. 36) rather than internally. ATGM use HEAT warheads; AAM have ABF, except for 70mm IRH with uses SAPHE.

Machine Gun, Autocannon, and Grenade Launcher Installation Table

Machine Guns

Weapon	Weight	Volume	Cost	Power	WPS	VPS	CPS	TL
7.62 × 51mm Machine Gun (M240; US)	23	0.46	$6,600	0	0.055	0.0004	$0.11(1)	7
7.62 × 54mmR Machine Gun (PKT; RU)	23	0.46	$2,800	0	0.052	0.0004	$0.1(1)	7
7.62mm × 51mm Chain Gun (L94A1; UK)	39	0.8	$19,500	0.25	0.055	0.0004	$0.11(1)	6
7.62mm × 51mm Minigun (M134; US)	59	1.2	$20,000	1.5	0.055	0.0004	$0.11(1)	7
12.7 × 99mm Machine Gun (M2HB; US)	84	1.7	$11,300	0	0.25	0.0017	$0.50(1)	6
12.7 × 108mm Machine Gun (NSV-12.7; RU)	55	1.1	$9,900	0	0.26	0.0017	$0.52(1)	7
12.7 × 99mm 3-bar. Minigun (GAU-19/A; US)	74	1.5	$25,000	2.5	0.25	0.0017	$0.50(1)	7
12.7 × 108mm 4-bar. Minigun (YakB-12.7; RU)	40	0.8	$20,000	3.3	0.26	0.0017	$0.52(1)	7
14.5 × 114mm Machine Gun (KPV; RU)	108	2.2	$17,000	0	0.46	0.003	$0.92(1)	7

Automatic Cannons

Weapon	Weight	Volume	Cost	Power	WPS	VPS	CPS	TL
20mm Autocannon (Rh202; GE)	183	3.7	$20,000	0	0.6	0.004	$2.40(2)	7
20mm 3-bar. Gatling (M197; US)	146	2.9	$23,000	2.2	0.57	0.0038	$2.30(2)	7
20mm 6-bar. Gatling (M168; US)	299	6	$40,000	17	0.57	0.0038	$2.30(2)	7
23mm Autocannon (AZP-23; RU)	176	3.52	$18,000	0	1	0.0067	$4(2)	7
23mm 2-bar. Autocannon (GSh-23; RU)	111	2.2	$18,000	0	0.76	0.0051	$3(2)	7
25mm Chain Gun (M242; US)	244	4.88	$40,000	2.2	1.1	0.0073	$4.40(3)	7
30mm Autocannon (2A42; RU)	253	5.1	$27,000	0	1.9	0.013	$7.6(2)	7
30mm Chain Gun (MK44 MOD 0; US)	324	6.48	$40,000	1.1	1.5	0.01	$6(3)	7
30mm Light Chain Gun (M230; US)	123	2.5	$50,000	2.2	0.77	0.005	$4.6(4)	7
40mm Autocannon (Bofors L70; SW)	770	15.4	$33,000	0	5.5	0.055	$11(5)	7

Grenade Launchers

Weapon	Weight	Volume	Cost	Power	WPS	VPS	CPS	TL
30mm AGL (AGS-17; RU)	39	0.8	$9,000	0	0.84	0.0084	$3(6)	7
40mm AGL (MK19 MOD 3; US)	72.5	1.45	$13,800	0	0.75	0.0075	$4.5(4)	7
40mm Electric AGL (M129; US)	45	0.9	$12,000	1.1	0.75	0.0075	$3(6)	7

Ammo Type: (1) Solid bullets; also uses AP (×3 cost) or API (×4 cost). (2) SAPHE; also uses API (×2 cost). (3) SAPHE; also uses APFSDS (×4 cost) or APFSDSDU (×6 cost). (4) HEDP. (4) HE; also uses APFSDS (×4 cost). (6) HE.

Mortar, Liquid Projector, and Heavy Cannon Installation Table

Mortars

Weapon	Weight	Volume	Cost	WPS	VPS	CPS	Ldr.	TL
60mm Mortar (Soltam C04; IS)	15	0.75	$2,200	3.8	0.038	$15(7)	1	7
81mm Mortar (L16A2; UK)	83	4.2	$14,000	9.2	0.092	$37(7)	1	7
120mm Mortar (Soltam K6; IS)	310	15.5	$20,000	31	0.31	$124(7)	1	7

Tank Guns

Weapon	Weight	Volume	Cost	WPS	VPS	CPS	Ldr.	TL
76mm Rifled Gun (D-56; RU)	2,500	50	$68,000	14	0.1	$56(8)	1	6
100mm Rifled Gun (D-10; RU)	4,285	85.7	$112,000	43/51	0.43	$200(8)	1	6
105mm Rifled Gun (L7A3; UK)	2,820	56.4	$150,000	40/48	0.5	$200(8)	1	7
120mm Smoothbore Gun (Rh120; GE)	4,191	83.8	$220,000	42/53	0.53	$850(9)	1	7
120mm Lg. Smoothbore Gun (CN-120-F1; FR)	5,760	115.2	$240,000	42/53	0.5	$850(9)	0	7
125mm Smoothbore Gun (2A46M; RU)	5,520	110.4	$110,000	46/60	0.6	$240(9)	0	7

Low-Pressure Cannon

Weapon	Weight	Volume	Cost	WPS	VPS	CPS	Ldr.	TL
76mm LP cannon (L23A1; UK)	331	6.6	$26,000	12	0.12	1	$48(10)	7
90mm LP cannon (CN-90-F1; FR)	880	17.6	$54,000	20	0.2	1	$80(10)	7
100mm LP cannon (2A70; RU)	726	14.5	$92,000	34	0.34	0	$140(10)	7

Liquid Projector

Weapon	Weight	Volume	Cost	WPS	VPS	CPS	Ldr.	TL
Water Cannon	80	1.6	$4,000	spcl.	spcl.	0(11)	0	7

Ammo: (7) HE or CHEM. (8) HE; also HEAT (×1.5 cost), APDS (×2.5 cost), APDS (×2.5 cost), and for 100mm+, APFSDS (×3 cost), APFSDSDU (×4.5 Cost). (9) APFSDS; also APFSDSDU (×1.5 cost), HEDP (×0.5 cost). (10) HE or HEAT (×1.5 cost). (11) Uses 0.5 gallons of water/shot; add water tank (8.5 lbs./gallon).

Weapon Tables Abbreviations

AGL = Automatic Grenade Launcher
ATGM = Anti-Tank Guided Missile
Bar. = Barrel
EU = European
FR = France
GE = Germany
IRH = Infrared Homing
IS = Israel
LP = Low Pressure
MCLOS = Manual Command to Line of Sight
RG = Radio Guided
RU = Russia
SACLOS = Semi-Automatic Command to Line of Sight
SALH = Semi-Active Laser Homing
SW = Sweden
UK = United Kingdom
US = United States

For ammunition abbreviations, see *Gun and Missile Ammunition*, pp. 10-11.

Gun/Launcher ATGM

The 100mm tank gun and 100mm LP gun are also available as gun/launchers that can fire a 100mm SALH ATGM (AT-10 Stabber; RU). Add 100% to cost and 54 lbs. and 1.1 cf to weight and volume for the upgrade. Missiles are 54 lbs., 1.1 cf, $10,000 each.

The 125mm tank gun is also available as a gun/launcher that can fire a 125mm SALH ATGM (AT-11 Sniper; RU). Add 100% to cost and 62 lbs. and 1.2 cf to weight and volume for the upgrade. Missiles are 62 lbs., 1.2 cf, $12,000 each.

Ammunition

Guns and launchers built into the vehicle require ammunition. Note that some weapons may have varying ammunition with different CPS and in some cases WPS.

For each weapon, decide how many shots it will have ready to fire, and if several types of ammunition available, what mixture of ammunition it normally carries. Calculate weight, volume, and cost of ammunition by multiplying the number of shots by its WPS, VPS, and CPS. Ammo goes in the same body or subassembly as the weapon, or an adjacent one.

Anti-Blast Magazine: Ammunition explosions endanger any military vehicle that uses large-caliber (20mm or more) ammunition or missiles. This option stores the ammunition in a special compartment designed to vector blast away harmlessly should it explode. Add 25 lbs. and $250 per cf (*or fraction thereof*) of ammo stored in it; there is no extra volume.

Weapon Accessories

A weapon can be equipped with one or more accessories. Those available here can link it to other weapons, adjust its arc of fire, or stabilize the weapon against the shaking and jostling associated with vehicle movement.

Links

Two or more weapons can be linked so one gunner can use all in a single Aim or Attack maneuver. Guns requiring loaders, as well as wire-guided missiles, may *not* be linked. Linked weapons should all face in the same direction, but do not have to be in the same location, except that weapons in an open mount (p. 18) can only be linked with other weapons in the same mount, and launchers can only link with other launchers. Weapons may be cross-linked to let different combinations be fired. $50 per set of weapons in link.

Stabilization Gear

Added to any weapon, the gear gyroscopically stabilizes it, keeping it on target regardless of vehicle movement. There are two levels: *Partial* (stabilized in elevation, +1 to cancel movement penalties) and *Full* (stabilized in all planes, +3 to cancel movement penalties, allows aimed fire past 1/2D range without losing Accuracy bonus).

This may also be added for cameras, to allow mobile photography.

Special Mountings

Normally, a weapon fires in the direction it (or its turret/open mount) is facing, with a limited arc of fire extending about 15° to either side, up or down. The following special mountings can further increase arc of fire. A mounting may only be of one type.

High-Angle Mounting: This points the weapon up so it can be used for high-angle indirect or anti-aircraft fire, while making it no longer usable for ordinary direct fire against any target whose elevation is less than the range. No extra cost, weight, or volume.

Mortars *must* have high-angle mounting.

Universal Mount: Added to a weapon (or camera) in a turret or open mount, this allows it to be used as both a normal mount *and* a high-angle mount.

Door Mount: Only available for weapons or cameras "concealed" in a body that face either right, left, or back. The weapon is mounted on a pedestal next to a door in the vehicle. When the door is open, the weapon can be fired out of it with a 45° horizontal and 45° vertical arc of fire, but the weapon and gunner can be attacked without benefit of vehicle armor; when the door is closed, the weapon and gunner are protected.

HUDWACs (Head Up Display Weapon Aiming Computers) and pupil scanners must go in the same body or subassembly as the gunner(s) who will use them; other systems can go anywhere. If optics or sensor, decide which direction it looks: front, back, right, left, top, or bottom. For universal coverage, install several or place them in turrets or open mounts. A separate dedicated targeting computer is required for each weapon or set of linked weapons to be assisted.

The digital datalink and dedicated targeting computer also requires software to function. This is a one-time cost per vehicle: $400 for datalink, $2,000 for targeting.

Stabilization and Special Mount Table

Type	*Weight*	*Volume*	*Cost*	*Note*
Stabilization				
Partial Stabilization	0.05	0.05	$5	-1 to movement penalties
Full Stabilization	0.1	0.1	$10	-3 to movement penalties
Special Mounts				
Door Mount	0.5	0.5	$1	
Universal Mount	0.5	0.5	$1	
High Angle Mount	0	0	0	

Weight, Cost, and Volume: The table shows the stabilization or mount's weight per lb. of weapon/camera empty weight, volume per cf of weapon/camera volume, and cost per pound of weapon/camera empty weight. Mounts and stabilization gear must go in the same part of the vehicle as the system they serve.

Instruments and Electronics

Vehicles may be equipped with a variety of instruments and electronic systems. Refer to the table below for weight, cost, and volume.

Instruments and Electronics Table

Radios

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
Radio, Short Range	0.5	0.01	$100	neg.	3-mile range
Radio, Medium Range	2	0.04	$400	neg.	30-mile range
Radio, Long Range	20	0.4	$1,200	0.04	300-mile range
add Scrambler	0	0	+$1,000	neg.	frequency-agile option for radio
Radio, Receive-Only	0.2	neg.	$40	neg.	car radio
Digital Datalink	1	0.02	$600	neg.	

Optics

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
Light Amp.	2	0.04	$400	neg.	night vision
Low-Light TV	1.25*	0.025*	$1,000*	neg.	
Searchlight	10*	0.2*	$500*	1*	max. 8 mile range.
Telescope	1*	0.02*	$40*	neg.	
Digital Recon or Movie Camera	50	1	$25,000	neg.	35mm film

Instruments and Electronics Table (Continued)

Navigation

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
Autopilot	5	0.1	$200	neg.	holds aircraft on course
Global Positioning System (GPS)	1	0.02	$200	neg.	satellite navigation
Military GPS	4	0.08	$3,000	neg.	more precise
Navigation Instruments	20	0.4	$1,000	neg.	compass, charts, etc.
IFF	10	0.2	$2,000	neg.	identify friend or foe
Transponder	5	0.1	$1,000	neg.	for civilian aircraft
Inertial Navigation System	40	0.8	$50,000	neg.	

Sensors

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
IR Searchlight	15*	0.3*	$1,000*	1*	max. 8 mile range
Radar, targeting	5*	0.1*	$4,000*	0.25*	max. 125 miles range
Radar, no targeting	2.5*	0.05*	$2,000*	0.25*	max 125 miles range
Thermograph	5*	0.1*	$16,000*	neg.	

Targeting Systems

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
HUDWAC	10	0.2	$5,000	neg.	
HUDWAC/Pupil Scanner	10	0.2	$20,000	neg.	
Laser Rangefinder	10	0.2	$4,000	neg.	5 mile range
Laser Designator	1*	0.02*	$400*	neg.	
Dedicated Targeting Computer	60	1.2	$15,000	neg.	+3 skill

ECM

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
Radar Detector	1	0.02	$100	neg.	
Advanced Radar Detector	20	0.4	$2,000	neg.	
Laser Sensor	1	0.02	$100	neg.	
IR Jammer, jam -2	50	1	$100,000	0.25	jams missiles
IR Jammer, jam -4	100	2	$200,000	0.5	jams missiles
Smoke/Decoy Discharger	20	1	$100	0	loaded
Smoke/Decoy Reload	10	0.5	$20**	0	

Recreational and Computing

Item	*Weight*	*Volume*	*Cost*	*Power*	*Description*
Computer Terminal	40	2	$1,000	neg.	A multi-function display
Small Computer	2	0.04	$1,000	neg.	A laptop-power computer
Sound System	20	1	$400	neg.	Stereo system plus radio (or flight recorder)

* This is per mile of range or power of magnification (for LLTV and telescopes). Max range is 7 miles for searchlights or IR searchlights and 25 miles for thermograph; a more practical range for most ground vehicle-mounted systems is about 3 to 5 miles. For LLTVs, treat any magnification of less than ×5 as ×5 when calculating cost (not weight or volume).

** Ordinary smoke is $10, other reloads are $20. Select from flares, smoke, hot smoke, or prismatic smoke.

Radar Options: One or more options may be taken for radars. "No targeting" (for search-only radars) halves weight, cost, and volume. The "air search" or "surface search" options (optimized for a particular mode, mutually exclusive) halve cost. The "imaging" option (millimetric radar) doubles weight and volume, and multiplies cost by 5.

Mast-Mounted Sights: A vehicle with TTR or CAR rotors may combine sensors, optics, rangefinders, and designators in a "mast mounted sight" atop its rotor. This adds 30% to the weight, volume, and cost of the systems so equipped. Ground vehicles may do the same with an extendible sensor mast: add 10% per foot it can be raised.

Vehicle Equipment Packages

The following packages can save time when designing a vehicle. They simply bundle together several standard features into a single purchase. The weight, volume, price, and power needs described cover every individual accessory listed in the package.

AFV Turret Package: Dedicated targeting computer with software, inertial navigation system, laser rangefinder, laser sensor, two medium-range radios with scramblers, military GPS, two smoke/decoy dischargers, two 8× telescopes, two 5-mile thermographs. 225 lbs., 5.7 cf, $237,740, neg.

AFV Body Package: Light amplification, full fire-suppression system. 202 lbs., 4.04 cf, $5,400, neg.

Civilian Helicopter Package: Autopilot, GPS, long-range radio, navigation instruments, 1-mile searchlight, transponder. 61 lbs., 1.22 cf, $4,100, 1.04 kW.

Combat Helicopter Package: Advance radar detector, autopilot, dedicated targeting computer with software, digital recon camera, HUDWAC with pupil scanner, IFF, IR jammer (-2), 10× LLTV, military GPS, navigation instruments, two long-range radios with scramblers, two smoke/decoy dischargers, two reloads (flares), 10-mile thermograph. 391.5 lbs., 9.63 cf, $344,840, 0.33 kW.

Luxury Auto Package: Burglar alarm, GPS, sound system. 21 lbs., 1.02 cf, $1,200, neg.

Police Package: Emergency lights and siren, medium-range radio, 0.4-mile radar (no targeting). 3 lbs., 0.06 cf, $1,250, neg.

Miscellaneous Components

The following additional equipment can be installed in vehicles:

Miscellaneous Equipment Table

Type	*Weight*	*Volume*	*Cost*	*Power*
Fire Extinguishers				
Fire Extinguisher System	150	3	$300	neg.
Compact Fire Suppression System	50	1	$500	neg.
Full Fire Suppression System	200	4	$5,000	neg.
Heavy Equipment				
Extendable Ladder	60	3	$100	0
Crane	1,000	20	$4,000	1
Wrecking Crane	1,100	20	$4,000	1
Power Shovel	300	0.6	$1,500	0.125
Winch	50	1	$400	0.05
Emergency				
Stretcher Pallet	50	40	$100	0
Emergency Lights and Siren	0	0	$50	neg.
Security				
Burglar Alarm	0	0	$600	neg.
High-Security Alarm	0	0	$3,000	neg.
Mutable License Plate	1	0.3	$500	neg.
Oil Spray	75	1.5	$500	0
Smokescreen	75	1.5	$350	0
Spike Dropper	75	1.5	$350	0

For extendable ladders, cranes, and wrecking cranes, weight, volume, cost, and power is per 6' feet of height. Lifting capacity of a crane is one ton per 6' of height; damage done by a wrecking crane's ball is 6d per 6' height. Double power is required for cranes with an electromagnet.

For power shovels and winches, weight, volume, cost, and power is per ST 10 (200 lbs.) of digging, hauling, or vertical lifting capacity, or, in the case of a winch, per 4,000 lbs. of towing capacity. Cable length of a winch may be ST to ST × 20 yards.

Location: Winches go in the body. Cranes and wrecking cranes must go in a turret. Other systems may be housed in the body, open mount, or turret. Fire extinguisher and suppression systems go in the body; they have outlets in various parts of the vehicle.

Controls and Crew Stations

A powered vehicle requires at least one crew member (the operator). If a vehicle is to maneuver or use weapons or other systems it must be manned: Install maneuver controls and assign crew stations, determine the crew requirement, and add necessary accommodations. Then consider environmental systems and safety systems.

Maneuver Controls

A vehicle automatically has one set of maneuver controls if it has a propulsion system. Decide what types of controls it uses: Mechanical or Electronic. Mechanical controls are free.

Electronic controls (fly or drive by wire) give better maneuverability, but cost $5,000 or 10% of the drivetrain's cost, whichever is more.

Weight, Volume, and Location: Maneuver controls have no extra weight or volume, but they should be assigned a location – usually in the body of the vehicle.

Duplicate Controls: Helicopters may have a second set of controls, to allow a co-pilot to fly the aircraft without leaving his seat. Duplicate maneuver controls weigh 50 lbs., occupy 1 cf; duplicate mechanical controls cost $100 or 1% of the drivetrain's cost, whichever is more; duplicate electronic controls cost half what the electronic controls cost.

Crew Stations

A crew station (sometimes called a "workspace" or a "station") is a position manned by a single crew member. It controls one or more vehicle systems, and includes a seat and console. Each station is assigned control of certain vehicular components, such as maneuver controls, weapons, or electronics, and these can only be controlled from that station.

Determine how many crew stations the vehicle needs and what they control. (In many vehicles, this is unnecessary: just assume the vehicle operator controls everything.) Each of these components must be assigned to a particular crew station: each set of maneuver controls, each ranged weapon, each electronic system. A station can be assigned to control multiple systems as long as no station controls a component assigned to another, different station. For most civilian vehicles, there's only one crew station: the driver or pilot.

Decide how many crew stations the vehicle requires, give each a descriptive name, and decide what each controls. E.g., a crew station in an automobile with maneuver controls would probably be named "driver." One in a modern tank that controlled the radio and sensors might be "commander." Then decide what type of crew stations are used:

Cramped Crew Station (CCS): This is a seat or workspace with little room. Typical of vehicles like race cars, small helicopters, or Russian tanks, where space is at a premium.

Normal Crew Station (NCS): This has somewhat more elbow room and is more comfortable to work at. Typical of most military ground vehicles and some civilian craft.

Roomy Crew Station (RCS): Roomy crew stations are typical of vehicles built for comfort, such as most civilian automobiles.

Exposed Cramped (XCCS), Normal (XNCS), or Roomy (XRCS) Crew Station: The same as any of the above crew stations, but open to the elements, with no side or top protection. It is typical of crew stations in vehicles like jeeps, race cars, or convertibles.

Cycle Crew Station: A compact control panel and seat entirely outside the vehicle. It is used on small vehicles like motorcycles. It can only be used on vehicles that require only one crew station, do not have streamlining, and which, at this stage in the design process, have less than 30 cf of components. The occupant is unprotected by vehicle armor.

Crew Requirements

Driver/Cyclist/Pilot: The only actual requirement is a vehicle operator. In a pinch, he can usually operate other vehicle systems, though he may be overworked if has to do too many tasks simultaneously (e.g., drive, fire weapons, *and* use the radar). For this reason, military vehicles (and some civilian ones) may have larger crews.

Co-Pilot or Relief: Common on helicopters, a co-pilot takes turns flying the aircraft, and when not doing so may act as a lookout, navigate, or operate sensors or weapons. Semi-tractors and long-haul vehicles may have a relief driver for round-the-clock driving.

Gunner: AFV and attack helicopters often have a gunner. He fires the main weapons on the vehicle, freeing the vehicle operator to maneuver instead of shooting.

Loader: If a weapon requires loaders, a crew member may be assigned to do the job, usually serving as a mechanic, and possibly operating a secondary weapon when not busy.

Commander: AFVs usually have one person as commander; in addition to supervising the other crew, he will serve as a lookout, operate radios, and man the vehicle's sensors. In vehicles with two-man crews, he may double as the vehicle's gunner.

Other vehicles may carry extra crew to perform specialized tasks. A tour bus may have a conductor or guide, an ambulance may have 1-2 attendants or paramedics, and so on.

Each crew station is a component. Determine its location in the vehicle, weight, volume, and cost:

Crew Station Table

Type	*Weight*	*Volume*	*Cost*
Cramped	20	20	$100
Normal	30	30	$100
Roomy	40	40	$100
Exposed	–	×0.5	–
Cycle	10	0	$50

Location: Cycle crew stations go in the body. Cramped, normal, or roomy crew stations may be placed in the body or in turrets.

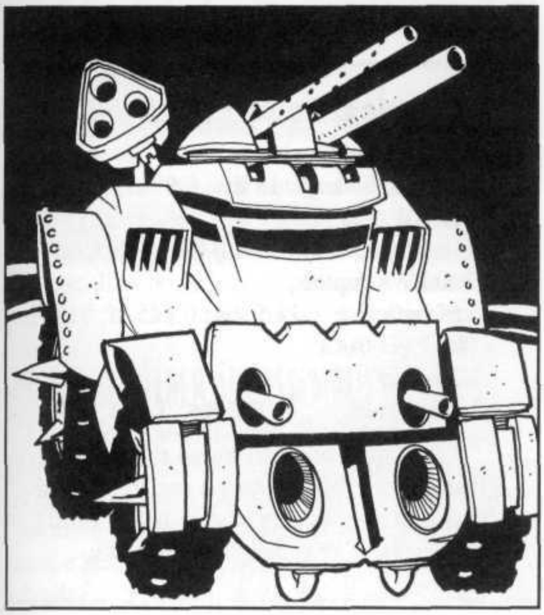
Passenger Seats and Standing Room

Seats are just that – a seat inside the vehicle that isn't assigned to control anything. They are divided into roomy, normal, or cramped seats, like crew stations. Roomy seats are typical of most front seats in comfortable cars, normal seats are like front seats in small cars and back seats in large ones, while cramped seats are typical of back or bench seats in mid-size or compact cars, commuter buses, or armored personnel carriers.

Standing Room is room for a person to stand, usually with a hand-hold. Like a seat, standing room is classed as cramped, normal, or roomy. Buses often have cramped standing room equal to their number of seats.

Exposed Seats or Standing Room are just like ordinary seats or standing room, except the occupant is partly outside the vehicle's structure. Jeeps and convertibles often use them.

Cycle Seats: If the vehicle has a cycle crew station, passengers are normally also in cycle seats.



The table shows the weight, volume, and cost of a single seat or standing room:

Seats and Standing Room Table

Type	*Weight*	*Volume*	*Cost*
Cramped Seat	20	20	$100
Normal Seat	30	30	$100
Roomy Seat	40	40	$100
Cramped Standing Room	0	20	0
Normal Standing Room	0	30	0
Roomy Standing Room	0	40	0
Exposed	–	×0.5	–
Cycle Seat	5	0	$50

Location: Seats or standing room may go in the body or turrets. Seats or standing room for loaders must be in the same location as the weapon or the ammunition loaded.

Folding Seats: A seat can be designed to be folded up and turned into cargo space. The cargo space produced is half the volume of the seat. The seat costs 5× normal.

Options for Occupants

Improved Access: Extra space can be added to vehicles with crew stations, seats, or spaces. It's common in buses. Add 50% to volume of all seats and crew stations; it allows occupants to move without displacing anyone else, and/or to recline the seats comfortably.

Airbags: These late TL7 safety systems can be added to protect crew. They must be placed in the same location as the crew station or seat they protect. Crew stations and seats can be assumed to come with safety belts or straps, if desired. 10 lbs., 1 cf, $200 per seat or crew station protected.

Brigs and Restraints: A crew or passenger seat can be equipped with manacles and/or bar or mesh screens separating it from other non-brig seats for +10% to seat cost. They are common on back seats in police cars.

Bunks: These are found in motor homes, sleeper cabs, etc. Includes laundry, wash, and waste-disposal facilities commensurate with number of occupants. 200 lbs., 100 cf, $100

Folding Bunks: A pair of roomy seats that occupy the same location in the vehicle can be built so that both the seats can be folded up to form a single bunk. This adds 50% to the combined seat weight and cost, but does not increase their volume.

Galley: A small galley for cooking is half the cost, weight, and volume of a bunk.

Luxury Interior: "Velvet glove" fittings, plush upholstery, nice seats, and various other amenities. Add 25 lbs., 0.5 cf, and $5,000 per seat or bunk in a compartment that is so equipped.

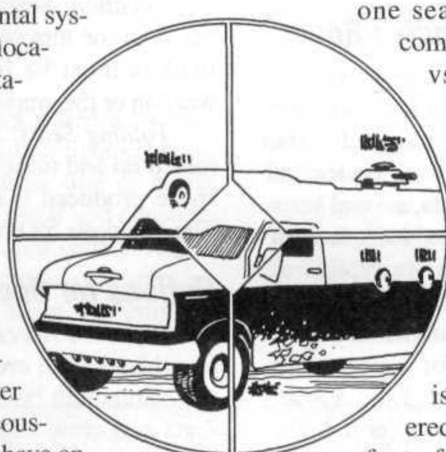
Environmental Systems

Environmental control is heating and air conditioning. NBC (Nuclear-Biological-Chemical) kits are filtration units that permit occupants to survive in a toxic or radiation-contaminated environment.

Environmental Systems Table

Type	Weight	Vol.	Cost	Power
Environmental Control	5	0.1	$50	0.25
NBC Kit	25	0.5	$5,000	0.25

Weight, volume, cost, and *power* are multiplied by the number of people the vehicle is designed to carry. Environmental systems should be located in a location that also houses crew stations or accommodations.



Energy Banks

An energy bank stores electrical power. A vehicle may have one instead of, or as well as, a power plant. If the vehicle's power plant output does not match the power requirements of all simultaneously operating systems, it must have an energy bank.

Power stored in an energy bank is measured in kilowatt-seconds (kWs). Each kWs of stored power provides the same power as a 1-kW power plant – but only for a second. Or it could provide 0.5 kW for 2 seconds, 0.001 kW for 1,000 seconds, and so on. Then the energy bank is drained of power until it is recharged.

To design an energy bank, decide how many kWs of power it will store. For comparison purposes, a typical car battery stores about 2,000 kWs. Then select the type of energy bank, and determine its statistics using the *Energy Bank Table.*

Energy Bank Table

Type	Weight	Cost
Lead-Acid Battery	0.02	$1.25
Advanced Battery	0.005	$10

Weight: This is per kWs of energy stored.

Volume: This is weight/200 for lead-acid, or weight/100 for advanced battery.

Cost: Per pound of energy bank weight.

Recharging: Batteries can be recharged by plugging into any power plant. Every second that 1 kW is channelled into the power cell restores 1 kWs of power.

Cargo Space

This is storage space inside the vehicle. It may range from a trunk or glove compartment to a giant cargo hold. A vehicle may have several different cargo spaces. Each is rated for its location in the vehicle and its volume in cubic feet. Cargo space can also be pressed in service for carrying standing passengers, at 20 cf per person.

Cargo spaces can be located in the body or turrets.

Hidden Cargo: If a vehicle has cargo space, some or all of it may be divided into one or more concealed secret compartments. If someone searches the vehicle, the secret compartment can be found on a roll vs. Holdout skill. Subtract 10; add +1 per 2% of vehicle's total volume that is "hidden." Hidden cargo costs $20 per cf of hidden space.

Open Cargo: Some or all of a vehicle's cargo (except for hidden cargo) can be designated as "open." This is a cargo bed whose upper half is open to the elements (or covered with a soft fabric). Each cubic foot of open cargo effectively takes up only one-half cf of space in the vehicle because of this.

Empty Space

Space may be left unused in the vehicle to provide "growth potential" for future modification, to just bulk up the volume, or to "even out" the size of a particular body or subassembly. Simply designate cubic feet of "empty space."

Typical Battery Designs

900 kWs motorcycle lead-acid battery	18 lbs., 0.09 cf, $22.50
2,000 kWs car lead-acid battery	40 lbs., 0.2 cf, $50
2,300 kWs copter adv. battery	11.5 lbs., 0.115 cf, $115
8,000 kWs truck lead-acid battery pack	160 lbs., 1.6 cf, $200

GMs may wish to halve the price of replacement mass-produced car, cycle, and truck batteries in the above (or similar) storage ranges, to reflect their ubiquity.

Volume and Structure

It's time to determine how big the vehicle is, and the statistics of its structure and armor.

Turret, Open Mount, and Body Volume

Determine the volumes of turrets, open mounts, and the body, in that order.

Each turret's volume is equal to the volume of all assigned components and unassigned empty space in it. If it has slope, increase this as shown on the *Body/Turret Volume Multiplier Table.*

Body volume equals the volume of all assigned components and unassigned empty space. If there are any attached turrets, add 10% of the turret's volume if limited rotation, or 20% if full rotation. If the body has streamlining or slope, its volume will be further increased: consult the *Body/Turret Volume Multiplier Table.*

Each open mount's volume is equal to the volume of empty space and assigned components in it, multiplied by 1.1 if limited or 1.2 if full rotation.

Body/Turret Volume Multiplier Table

Body Features	*Volume*
Body only:	
Body has Fair Streamlining	×1.1
Body has Good Streamlining	×1.2
Body or Turret has:	
30° slope	×1.1
60° slope	×1.25
90° slope	×1.4
120° slope	×1.6
150° slope	×2
180° slope	×2.5
210° slope	×3.3
240° slope	×5

Multiply volume by the number shown to determine the actual external body or turret volume. Slope is the sum total of all slope on that body or turret, e.g., if a body has 30° slope on back and 60° on its front, it has 90° for a ×1.4 to volume. If a body has slope *and* is streamlined, multiply first for streamlining, then for slope.

Volume of Other Subassemblies

Other subassemblies don't contain components, but still have a volume, which is taken up by their structure (such as wheels' suspension). Calculate their volume based on the body's volume, e.g., if a truck body was 200 cf, its heavy wheels subassembly is 40 cf.

Other Subassembly Volume Table

Subassembly	*Volume*
Small Wheels or Skids	0.05 × body volume
Standard Wheels	0.1 × body volume
Heavy or Off-Road Wheels	0.2 × body volume
Tracks	0.6 × body volume
Stub Wings	0.02 × body volume, per wing
Top-and-Tail Rotor or Coaxial Rotor	0.02 × body volume
Multiple Main Rotor	0.02 × body volume, for each of two rotors
Pontoons	0.2 × body volume

If desired, wheels and tracks can be *larger.* Wheels of 1.5 times the listed size are common on some off-road vehicles, and 4 to 6 times listed size is typical of some monster trucks.

Surface Area

Each body or subassembly is rated for its surface area ("area"), an approximation of the body or subassembly's area in square feet.

Calculate surface area individually for the body and then for each distinct subassembly. Look up that body or subassembly's real volume in the "volume" column, and then read the surface area from the "area" column to the right of it. If a value falls between two numbers, use the lower. If a wing, double the area. If a rotor, triple the area.

VOLUME AND STRUCTURE

It's time to determine how big the vehicle is, and the statistics of its structure and armor.

TURRET, OPEN MOUNT, AND BODY VOLUME

Determine the volumes of turrets, open mounts, and the body, in that order.

Each turret's volume is equal to the volume of all assigned components and unassigned empty space in it. If it has slope, increase this as shown on the *Body/Turret Volume Multiplier Table.*

Body volume equals the volume of all assigned components and unassigned empty space. If there are any attached turrets, add 10% of the turret's volume if limited rotation, or 20% if full rotation. If the body has streamlining or slope, its volume will be further increased: consult the *Body/Turret Volume Multiplier Table.*

Each open mount's volume is equal to the volume of empty space and assigned components in it, multiplied by 1.1 if limited or 1.2 if full rotation.

Body/Turret Volume Multiplier Table

Body Features	*Volume*
Body only:	
Body has Fair Streamlining	×1.1
Body has Good Streamlining	×1.2
Body or Turret has:	
30° slope	×1.1
60° slope	×1.25
90° slope	×1.4
120° slope	×1.6
150° slope	×2
180° slope	×2.5
210° slope	×3.3
240° slope	×5

Multiply volume by the number shown to determine the actual external body or turret volume. Slope is the sum total of all slope on that body or turret, e.g., if a body has 30° slope on back and 60° on its front, it has 90° for a ×1.4 to volume. If a body has slope *and* is streamlined, multiply first for streamlining, then for slope.

VOLUME OF OTHER SUBASSEMBLIES

Other subassemblies don't contain components, but still have a volume, which is taken up by their structure (such as wheels' suspension). Calculate their volume based on the body's volume, e.g., if a truck body was 200 cf, its heavy wheels subassembly is 40 cf.

Other Subassembly Volume Table

Subassembly	*Volume*
Small Wheels or Skids	0.05 × body volume
Standard Wheels	0.1 × body volume
Heavy or Off-Road Wheels	0.2 × body volume
Tracks	0.6 × body volume
Stub Wings	0.02 × body volume, per wing
Top-and-Tail Rotor or Coaxial Rotor	0.02 × body volume
Multiple Main Rotor	0.02 × body volume, for each of two rotors
Pontoons	0.2 × body volume

If desired, wheels and tracks can be *larger.* Wheels of 1.5 times the listed size are common on some off-road vehicles, and 4 to 6 times listed size is typical of some monster trucks.

SURFACE AREA

Each body or subassembly is rated for its surface area ("area"), an approximation of the body or subassembly's area in square feet.

Calculate surface area individually for the body and then for each distinct subassembly. Look up that body or subassembly's real volume in the "volume" column, and then read the surface area from the "area" column to the right of it. If a value falls between two numbers, use the lower. If a wing, double the area. If a rotor, triple the area.

Area Table

Volume (cf)	Area (sf)	Volume (cf)	Area (sf)	Volume (cf)	Area (sf)	Volume (cf)	Area (sf)
under 0.03	0.5	3.3-3.5	14	25-31	60	3,376-6,080	2,000
0.03-0.06	1	3.6-3.9	15	32-44	75	6,081-8,495	2,500
0.07-0.12	1.5	4.0-4.3	16	45-68	100	8,496-11,180	3,000
0.13-0.19	2	4.4-4.7	17	69-95	125	11,181-17,185	4,000
0.2-0.26	2.5	4.8-5.1	18	96-125	150	17,186-24,110	5,000
0.27-0.3	3	5.2-5.6	19	126-157	175	24,111-35,650	6,500
0.4-0.5	4	5.7-6.0	20	158-188	200	35,651-48,650	8,000
0.6-0.75	5	6.1-6.5	21	189-268	250	48,651-68,025	10,000
0.8-1.0	6	6.6-7.0	22	269-353	300	68,026-89,440	12,000
1.1-1.25	7	7.1-7.4	23	354-543	400	89,441-125,000	15,000
1.3-1.5	8	7.5-8.0	24	544-759	500	125,001-192,420	20,000
1.6-1.8	9	8.1-8.4	25	760-1,000	600	192,421-268,960	25,000
1.9-2.2	10	8.5-9.5	27	1,001-1,540	800	268,961-353,450	30,000
2.3-2.5	11	9.6-11	30	1,541-2,150	1000	353,451-544,335	40,000
2.6-2.8	12	12-17	40	2,151-2,830	1200	544,336-760,610	50,000
2.9-3.2	13	18-24	50	2,831-3,375	1500	760,611-1,000,000	60,000

Once the surface areas of the body and all subassemblies are known, find the *Total Area* by adding together all their surface areas. For example, a truck with a 330 cf body has area 300; its 66 cf wheels have area 100; total area is 400. Then record the *Structural Area,* which is the total area *excluding* open mounts.

Structural Weight and Cost

After area is calculated, the vehicle's internal skeleton and frame – its structure – is designed. Select a *frame strength* and *materials* from the table below, and use the table to find the vehicle's structural weight and cost.

Vehicle Structure Table

Frame Strength

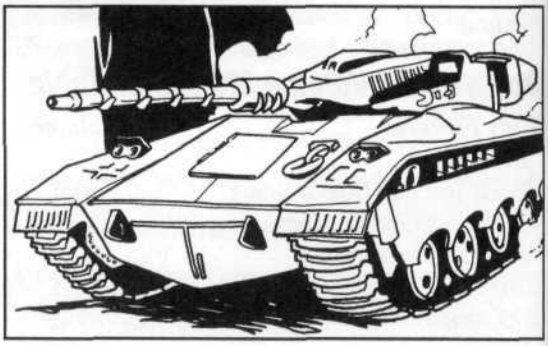
Feature	Weight	Cost	Examples
Light	3	$25	car, civilian copter, light cycle
Medium	6	$50	light truck, military copter, heavy cycle
Heavy	9	$100	heavy truck, light AFV
Extra-Heavy	12	$250	main battle tank, semi tractor

Materials

Feature	Weight	Cost	Examples
Very Cheap	×2	×0.2	heavy steel
Cheap	×1.5	×0.5	steel, aluminum
Standard	×1	×1	aluminum, steel
Expensive	×0.75	×2	alloy, composites
Very Expensive	×0.5	×5	all composites

Other Modifiers

Feature	Weight	Cost
If vehicle has rotors	×1	×10
If Fair streamlining	×1	×1.2
If Good streamlining	×1	×1.5



Weight: Multiply the vehicle's structural area by the basic design weight shown for the frame, and then by every applicable multiplier in the *weight* column to get structural weight.

Cost: Multiply the structural area by the basic design cost for the frame and then by every applicable multiplier in the *cost* column to get structural cost.

Example: A truck we're building has a 400 sf structural area. We choose a heavy frame and very cheap materials. Structural weight is 400 (total area) × 9 (heavy) × 2 (very cheap) = 7,200 lbs. Cost is 400 (total area) × $100 (heavy) × 0.2 (very cheap) = $8,000.

Open Mount Weight and Cost

As these are attached outside the vehicle's structure, their weight and cost are calculated independently. Each open mount weighs 6 lbs. × its area and costs $10 × its area. For example, a 2.2 cf open mount (area 10) is 60 lbs. and $100.

Hit Points

Once the vehicle's structure has been determined, find the hit points for the vehicle's body and for each subassembly:

Structure	*Hit Points*
Body	the body's area × 1.5
Each Turret or Stub Wing	its area × 1.5
Each Rotor	its area × 3
Skids, Pontoons, or Tracks	area × 1.5
Wheels	3 × wheels' area

Divide hit points by 2 for a light frame. Multiply by 2 for a heavy frame or 4 for an extra-heavy frame. Round to the nearest whole number.

In the case of wheels, split the hit points evenly among wheel positions; e.g., for 80 hit points and four wheels, each wheel has 20 hit points. In the case of tracks or skids, divide the hit points between each of the two tracks or skids.

Special Structural Options

These enhance performance or safety characteristics (see *Performance,* p. 38-40).

Improved Suspension: Typical of sports, luxury and race vehicles, and some tanks. Costs $100 × motive subassembly's surface area.

Improved Brakes: Represents antilock braking system (ABS). Available only for wheels. Costs $20 × wheel subassembly's surface area.

Heavy Compartmentalization: The vehicle's interior is carefully configured to reduce the spread of fire or mitigate battle damage; this is common on tanks. Adds cost *and* weight. Weighs one-tenth the vehicle's structural weight divided by structural area and multiplied by the combined area of body and turret. It costs $5 per pound.

Armor

This is a vehicle's hull. "Armor" is both the ordinary surface skin – whether it is metal or other material – and actual armor plate. Vehicular armor is rated for its Damage Resistance (DR), the location it covers, and the type of armor material.

A vehicle with slope, streamlining, or rotors *must* have armor! Other vehicles *may* have armor. Many vehicle designs have more or less the same armor *everywhere*. Most civilian vehicles, like cars and trucks, have this sort of armor, e.g., DR 5 cheap metal overall. Or, a vehicle can vary armor type, quality, and DR by subassembly. E.g., an APC may have a body with DR 150 standard metal, but DR 50 cheap metal on its tracked subassembly.

Examine the *Armor Table* and pick a type and quality of armor (e.g., cheap metal). Using the values already calculated for the vehicle's structural surface area (see p. 32), decide on the surface area that will be armored (in sf): this may be either the vehicle's total area if the same armor will be used everywhere, or the surface area of the body or an individual subassembly, if giving different armor to each location. Decide on the DR the armor will have (see *Typical Real-World DR Values*, p. 34). Determine the armor's weight and cost:

Armor weight =
DR × area armored (sf) × weight modifier (WM).

Armor cost =
calculated armor weight × cost modifier (CM).

Weight and cost modifiers depend on the chosen armor type and quality: see *Armor Table,* p. 34.

A turret or body can optionally be given armor whose DR varies by facing. Bodies have six faces: front (F), back (B), right (R), left (L), underside (U), and top (T). Turrets have five sides: exclude the side attached to the body, e.g., underside. To give armor to a single facing, use 1/6 the listed surface area for body or 1/5 surface area for a turret.

Armor Table

	WM	CM	Example
Metal			
cheap	0.6	$1	basic steel
standard	0.5	$2	rolled homogenous armor
expensive	0.4	$6	aluminum and steel
Composite			
standard	0.4	$5	fiberglass and other light composites
expensive	0.25	$15	ballistic fibers and carbon composites
advanced	0.15	$50	ceramic and boron composites
Laminate			
standard	0.4	$10	spaced armor, or steel-aluminum-plastic "sandwich armor"
expensive	0.25	$30	Chobham laminate
advanced	0.15	$100	Chobham with depleted uranium mesh

Slope Effects: If a body facing or turret facing has slope, multiply final DR by 1.5 for 30° or 2 for 60° slope. No effect on weight or cost.

Open Frame Armor: This can represent a roll cage or other open framework. Its DR fully protects vs. collisions, falls, and swinging melee attacks, but only has a 2-in-6 chance of protecting against other attacks, and provides no benefit at all vs. fire or explosion. Open frame armor gets no benefit from slope, but is one-fifth normal armor weight and cost. It cannot be used with vehicles that are streamlined, waterproofed or sealed.

Wheelguards and Track Skirts: Wheels and tracks can be given armored guards that only protect their upper half; either instead of or as well as completely armoring the assembly. These skirts can also be retrofitted. Build these as normal subassembly armor, using only half the subassemblies area. These skirts and guards do not protect against attacks from below, and only protect against attacks from other directions on a 1-4 on 1 die.

Other Protective Features

Waterproofed: The vehicle will not leak if floating or suffer corrosion from salt water.

Sealed: The vehicle is waterproofed, but also protected against corrosion and the effects of sudden pressure changes, or high or low temperatures. It may have an NBC Kit (p. 10) to protect against CBW agents. It must have DR 1+ over its entire body.

Spall Liner: An internal ballistic liner added to a body or turret to reduce occupant casualties.

Infrared Cloaking: A variety of signature-reduction methods that reduce the likelihood of infrared and thermograph (IR cloaking) detection.

Typical Real-World DR Values

Stumped as to what DR to use? Most civilian vehicles have cheap or standard metal with DR 3-7; race cars and helicopters often use composites instead. Armored cars, helicopters, and AFVs usually have DR sufficient to resist the average damage from a typical threat.

Typical threat levels and the DR values needed to, on average, provide protection against them:

Only half the described DR will be needed to defeat threats at long range (beyond 1/2D range). Civilian armored cars usually have DR 10-18; most light AFV have DR 50-100 on the front and DR 25-70 elsewhere. MBTs usually have, after modifiers for slope, DR 500-1,800 on front body and front turret, with DR 50-350 on other facings and subassemblies.

Threat Level	*Suggested DR*
Pistol or SMG bullets and grenade fragments	DR 10+
5.56mm rifle	DR 18+
7.62mm rifle or light MG	DR 24+
if AP bullets	DR 50+
20mm SAPHE cannon shells	DR 30+
12.7mm heavy MG	DR 45+
if AP bullets	DR 90+
20mm AP cannon shells	DR 125+
30mm AP cannon shells	DR 200+
RPG-7 portable anti-tank weapon	DR 630+
if laminate	DR 315+
125mm tank gun APFSDS ammo	DR 1,100+

Protective Features Table

Type	*Weight*	*Cost*	*Power*
Waterproofed	0	$2	0
Sealed	0	$40	0
Basic Infrared Cloaking	2	$300	0
Spall Liner	0.36	$3.6	0

Multiply cost by the vehicle's total surface area, except for spall liner, which uses the area of the body or turret so protected.

Other External Features

After all components have been installed, the vehicle can be completed. Alternatively, a variety of miscellaneous features can be added to the exterior of a vehicle.

Explosive Reactive Armor

Blocks of reactive armor can be applied to a ground vehicle over regular armor. Any side but the underside may be protected; use the rules for applying armor to individual facings. The Reactive Armor Plates (RAPs) may be attached to any body or turret with DR 50+. RAP protection weighs 8 lbs. and costs $20, multiplied by the surface area of the protected facing (e.g., 1/6 body area to protect the front body, etc.).

Plows and Bulldozer Blades

These are earthmoving or mine-clearing blades attached to the vehicle's front. They can be added to any vehicle with standard, heavy, or off-road wheels, or tracks. They can clear or plow a path as wide as the vehicle. They weigh 2 lbs. × body area and cost $4 × body area.

Convertible Top Features

Convertible Hardtop: A vehicle with six or fewer crew and/or passenger seats, excluding exposed seats, may have a detachable hardtop. It may not have top-mounted turrets. When the hardtop is removed, the seats are treated as exposed seats, giving a better all-around view but reducing the protection against attacks or the elements, and (if the vehicle is sealed) unsealing it. It takes 10 seconds to attach or remove the top. $100 per seat.

Convertible Ragtop: A vehicle with exposed seats may have a fabric top. When down, the top restricts overhead vision, but protects against weather conditions. The top is designed to fold up automatically. 5 lbs. and $50 per exposed seat.

Rooftop Fairings

A late TL7 add-on popular for semi-tractors as a cheap alternative to streamlining. Available for unstreamlined wheeled vehicles: 0.1 lbs. and $1 × body area.

Special Tires

Normal tires are included in the cost of wheeled subassemblies. However, vehicles may have more expensive tires. Cost is based on the number of wheel positions that the vehicle's wheeled subassembly has. The available types include:

Snow Tires add +2 to Driver skill – but only to cancel the penalty for driving on snow with a wheeled vehicle! They cost an extra $100 per wheel ($200 per wheel if the wheeled subassembly's surface area is 200 sf or larger).

Racing Tires improve maneuverability as long as they are used on a smooth-surfaced race track. Used on normal roads, they take 1 hit of damage per hour (per *minute* off-road). They cost an extra $250 per tire ($500 per tire if the vehicle's wheeled subassembly is 200 sf in area or larger). They add +0.25 to gMR.

Puncture-Resistant (PR) Tires give tires a DR of 3 instead of DR 2. They cost an extra $250 per tire ($500 per tire if the wheeled subassembly is 200 sf in area or larger). They are "run flat" designs that effectively regenerate damage (to the tire, not the wheel) at 1 hit per turn.

Hitches and Pins: Pulling Other Vehicles

A vehicle can be equipped to pull another vehicle along, or be built to be towed itself. Normally only vehicles equipped with wheels or skids are built to be towed.

Hitch: This is a hook, "fifth wheel," or other device that enables a vehicle to pull another vehicle. A hitch weighs 0.1 lbs. and costs $0.1, both multiplied by the vehicle's body hit points. A hitch allows it to tow a vehicle that weighs up to 50 lbs. times the towing vehicle's body hit points. Attaching or detaching a hitched vehicle takes at least 10 seconds and must be done from outside the vehicle. A remote-controlled hitch that can be detached from inside a towing vehicle is available for double cost.

Pin: A vehicle that is designed to be towed requires a *pin*. A pin weighs 0.1 lb. and costs $0.05, both multiplied by the vehicle's body hit points. An *explosive* pin is available for five times the cost. This allows the towed vehicle to be released instantly as a combat action, either from within the towing vehicle or the towed vehicle (designer's choice). A vehicle can have both a pin and a hitch.

Hardpoints

Hardpoints are reinforced points and pylons on a vehicle's body or wings to which external, jettisonable "stores" such as missiles can be attached. Bodies, turrets, and wings can have hardpoints.

Each hardpoint is rated for the maximum weight it can carry – its load capacity. Within these weight limits, a single hardpoint may carry up to six identical stores.

If a vehicle will have hardpoints, decide how many the body and each wing has. Then determine the load capacity (in pounds) of each hardpoint. The number and capacity of hardpoints on each wing should be the same.

A single wing or body may have a number of hardpoints whose *total* load capacity is no greater than 20 lbs. × its hit points (see *Hit Points,* p. 33). For each pound of load capacity, hardpoints are 0.05 lbs. and costs $0.1.

Hardpoints are assumed to be "tapped," to let the vehicle draw fuel from drop tanks and provide power to pods containing electronics. An untapped hardpoint costs half as much; it can only carry and drop unpowered weapons.

Control of all a vehicle's hardpoints (which includes firing weapons) must be assigned to one of the vehicle's crew stations, usually the same one that handles maneuver controls.

Hardpoint Stores

Anti-Tank Missiles: The 178mm SALH (Hellfire) and 130mm RG (Ataka) missiles are directly attached to hardpoint pylons. Other ATGM (e.g., TOW, HOT, MILAN, AT-6) used on hardpoints must be in light disposable tube launchers (0.5 lbs. × WPS and $25 × WPS for single mount; multiply by 1.4 for double mount or 2.2 for quad mount).

Air-to-Air Missiles: An 127mm IRH-AAM (AIM-9 Sidewinder, US) with WPS 185, CPS $83,000 or a 170mm IRH (AA-11 Archer, RU) with WPS 253, CPS $100,000 can be attached directly, singly or in pairs, to hardpoint pylons, as can 70mm (Stinger) and 90mm (Mistral) AAMs (see *Missile Installation Table,* p. 22).

Unguided Rocket Pods: One of the most common hardpoint stores are pods of unguided rockets. Typical rocket pods are described below.

Equipment Pods: These can be attached to a hardpoint instead of missiles or rockets. Pods may contain fuel (drop tanks), electronics, or weapons and their ammunition (gun pods); weapons requiring loaders are not appropriate. An equipment pod is built as it were a vehicle body with no subassemblies: typically light with DR 1-3 composite armor. It can (if on a tapped hardpoint) draw power from the vehicle. Its only relevant statistics are hit points, DR, PD, loaded weight, and cost.

Unguided Rocket Pod Table

Type of Pod	*Weight*	*Cost*
70mm 7-shot pod (M260 w/ Hydra 70 rockets, US)	245	$10,000
70mm 19-shot pod (M261 w/ Hydra 70 rockets, US)	650	$26,000
80mm 7-shot pod (B-8V-7 w/S-8 rockets, RU)	262	$8,000
80mm 20-shot rocket pod (B-8V-20 w/S-8 rockets, RU)	770	$21,000

Weight and cost are for a loaded pod.

Small Details

Doors and Hatches: All vehicles large enough to need them are assumed to come with normal doors or hatches. On sealed vehicles, these are airtight. Vehicles will usually not have more than one door per 25 sf or fraction of body or turret surface area, and will often have fewer. The GM should prohibit any designs that abuse this.

Cargo Ramp: A vehicle with 50 cf or more of cargo space (or 6+ passengers) may also have a large back or front drop ramp at no extra cost.

Vision: For each body or subassembly that contains seats, spaces, or quarters, decide whether its occupants have a "good view" (like a car), "fair view" (like a truck, with restricted back vision), or "poor view" (like a tank) out of any canopy or windows. Exposed or external seats or spaces always have a good view. See p. 51, for *Visibility and Windows.*

Headlights: All powered vehicles have lights (for "free") that clearly illuminate an area in front of the vehicle for about 35 yards and that can be seen at 20 times that distance. These are sufficient for normal nighttime travel. The lights also cut fog penalties by half.

Locks and Keys: The familiar *ignition key* is standard on civilian vehicles with internal combustion power plants. Turning on the power plants of military ground vehicles (and most aircraft) doesn't require an ignition key – they just have a starter knob.

Safety Belts: Most seats include these for "free," but not all vehicles have them.

Reverse-Engineering Vehicles: The 20% Rule

GURPS Vehicles Lite is a metasystem that applies simple formulae to complex subjects. While the system usually produces reasonable results, a vehicle or component built using this system may vary somewhat from any one particular real-world example. If this happens, the GM should feel free to change it. A +/- 20% change will usually suffice, and shouldn't affect game balance much, provided it's the GM who does the adjusting.

Evaluating Statistics and Performance

Everything the vehicle needs is now installed or attached. Now we find out what it can do!

Weight and Mass

Payload: Decide on a "usual internal payload" for the vehicle, in lbs. This is the normal maximum weight of occupants and cargo carried. For most vehicles, we suggest a "generic" payload of 200 lbs. per occupant. This gives the average weight of a human, plus an extra third to cover worn or carried gear and weight variations. Then add 20 lbs. per cf of cargo space to represent a normal load of cargo. However, different loads are possible. For example, a helicopter (with limits on the weight it can lift) may have cargo space it does not use if carrying a full passenger load.

Loaded Weight: Add up the weight of all vehicle components, structures, and features, including fuel and ammo, and add that to the weight of the payload. This is the loaded weight. If the vehicle has hardpoints, also record a "weight with hardpoints loaded" equal to the loaded weight plus the maximum load of the hardpoints. When performance calculations call for loaded weight, calculate two values, one with and one without the hardpoints loaded.

Empty Weight: This is the loaded weight minus the weight of payload, fuel, and ammunition. ("Curb weight" is weight with fuel but without payload.)

Design Check! If the vehicle has a maximum lift, make sure the loaded weight does not exceed these values. If it does, redesign the vehicle to reduce its weight. This can be done fairly easily by converting cargo space to empty space to reduce usual payload, or by eliminating armor.

Loaded Mass in Tons: If the weight checks out, find the loaded mass in *tons*. Divide the loaded weight by 2,000 to get it. (If the vehicle has hardpoints, calculate two loaded masses.) Round to two decimal places.

Vehicle Volume and Size Modifier

Add up the volumes of the body and all subassemblies. This is the vehicle volume. Use the table below to find the Size Modifier (see p. B116). The volume will probably fall between two entries on the table; use the higher one to find Size Modifier.

Size Modifier

Volume	*Modifier*	*Volume*	*Modifier*
0.1	-4	3,000	+5
0.3	-3	10,000	+6
1	-2	30,000	+7
3	-1	100,000	+8
10	+0	300,000	+9
30	+1	1,000,000	+10
100	+2	3,000,000	+11
300	+3	10,000,000	+12
1,000	+4	etc.	etc.

Price

Add up the total cost of everything built into the vehicle except for ammunition and fuel to find out the cost. This approximates actual price, but remember that real vehicle prices vary dramatically, even for the same model. Price for military equipment, racing vehicles, and helicopters and their ammunition sometimes comes out low, as cost assumes mass production. It can be realistic to multiply by 2-5 for brand-new vehicles (and ammo); on the other hand, the list price is a good value for second-hand or obsolete military vehicles.

Health

This measures structural and mechanical robustness. The heavier a vehicle is compared to its structural strength, the more strain it puts on its systems and so the lower its HT will be. A vehicle can have a low Health but many hit points. Structural HT is calculated as follows:

$$HT = (200 \times BHP/Lwt.) + 5.$$

BHP = body hit points. *Lwt.* = loaded weight.

Round HT to the nearest whole number. If the vehicle has hardpoints, always use the weight with hardpoints loaded – do not calculate two different values. If the vehicle has a racing engine, HT is -1. The maximum HT allowed is 12 (11 if a racing engine).

Maintenance Interval (MI)

This indicates how many hours the vehicle can operate before requiring routine maintenance (p. 51). To calculate MI in hours, divide 20,000 by the square root of vehicle empty cost.

Armor PD and DR

Record the DR of the body and each subassembly. If necessary, record separate DR values for different faces. Passive Defense (PD) is also determined for each location, based on DR of the armor, according to the following table:

PD Table

DR	*1*	*2-4*	*5-15*	*16+*
PD	1	2	3	4

Slope and PD: As well as possibly increasing PD by boosting DR, slope will further increase Passive Defense on the sloped faces:

30° slope adds +1 to PD on the sloped face.

60° slope adds +2 to PD on the sloped face.

Ground Performance

A vehicle has a ground performance – that is, it can move on the ground – if it has wheels or tracks. Each of these methods is referred to as a particular "motive system."

Ground Speed and Ground Acceleration

Ground speed (gSpeed) is the top speed the vehicle can reach on the ground. Speed is measured in mph.

Ground acceleration (gAccel) is measured in mph per second. It is the maximum by which a vehicle moving on the ground can increase its speed each second until top ground speed is reached. Note that gAccel is averaged over the vehicle's entire speed.

Divide the tracked or wheeled drivetrain's motive power by the loaded mass in tons. Find the square root of the quotient. Multiply the result by 0.8 to get gAccel and by *speed factor* (see below) to get the gSpeed.

Speed Factor Table

Motive System	*Speed Factor*
Wheels	16
Tracks	12

An improved suspension adds 2 to the speed factor of wheels and 1 to the speed factor of tracks.

Streamlining Effects and Speed Limits: If speed works out to 50 mph or more and the vehicle has streamlining, add 3% to top speed for a rooftop fairing, 5% to top speed for Fair streamlining or 10% for Good streamlining. Top speed can never exceed 600 mph unless the vehicle has Good or better streamlining.

Round all fractional speeds to the nearest whole number. If gSpeed is 20 mph or more, optionally round to the nearest 5 mph. If gAccel is over 5 mph/s round to the nearest 5 mph/s.

Extra Detail

At very high speeds, drag reduces actual speed more severely than indicated in the formula. If gSpeed, *after applying streamlining modifiers,* exceeds 121 mph (for no streamlining), 144 mph (for fair streamlining), or 169 mph (for good streamlining), find the *base* speed's square root, then multiply by 11 (no streamlining), 12 (if fair streamlining) or 13 (if good streamlining) to get the actual corrected gSpeed.

Ground Deceleration (gDecel)

This is the maximum deceleration in mph per second safely possible while maneuvering on the ground. gDecel depends on the motive system in use:

Ground Deceleration Table

Motive System	*gDecel*
Skids	5 mph/s
Wheels	10 mph/s*
Tracked	20 mph/s

* Improved brakes add 5 mph/s.

Ground Stability and Maneuver Ratings

Ground Stability Rating (gSR) is a measure of stability when moving on the ground.

Ground Maneuver Rating (gMR) is the maximum *safe* "G" (gravities) the vehicle can pull while maneuvering on the ground.

Both gMR and gSR are determined using the table on the following page: cross-index the motive system the vehicle is using and the vehicle's body volume and find the results in the gMR and gSR columns. Then apply the modifiers shown below the table.

gMR and gSR Table

Body's Volume										
Motive	*under 30 cf*		*31-101 cf*		*101-300 cf*		*301-3,000 cf*		*3,001+ cf*	
System	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*
Skids	1.25	2	1	3	0.75	3	0.25	4	0.125	4
1 Wheel	1.5	1	1.25	1	0.5	1	0.25	1	0.125	1
2 Wheels	1.5	2	1.25	2	0.5	2	0.25	2	0.125	2
3 Wheels	1.25	2	1	3	0.75	3	0.25	4	0.125	4
4-6 Wheels	1	3	0.75	4	0.75	4	0.5	4	0.125	4
8+ Wheels	0.75	3	0.5	3	0.25	4	0.25	5	0.125	5
Tracks	0.5	3	0.25	4	0.25	5	0.25	6	0.125	6

gMR Modifiers: The following enhancements each add 0.25 to gMR: improved suspension, electronic controls, and, for wheels only, all-wheel steering. *Exception:* if the gMR began at 0.125, the first enhancement increases it to 0.25, then any subsequent enhancements add 0.25 each. Regardless of motive system or enhancements, gMR cannot exceed 0.5 if the vehicle has small wheels.

gSR Modifiers: Improved suspension adds 1 to gSR. Small wheels subtract 1 from gSR.

Option: Vehicles with wheeled or tracked drivetrains and manual controls may be designated to be utilizing a transmission that is either "automatic" or "manual." An automatic provides +1 to Driving if the driver has Driving-10 or less, but -1 to Driving if the driver has Driving-13 or more. A manual transmission has no modifier, but there is a -3 unfamiliarity penalty if the driver has only driven automatics.

Ground Pressure and Off-Road Speed

Ground pressure is how much force the vehicle's motive system exerts on a given square foot of ground. It is the weight of the vehicle divided by the nominal area the vehicle has in contact with the ground.

The contact area of the vehicle can be determined as follows:

Contact Area Table

Motive System in Use	*Contact Area Equals*
Off-road Wheels	wheel surface area/33
Other Wheels	wheel surface area/50
Tracks	track surface area/5
Skids	skid surface area/10

Divide the loaded weight of the vehicle in pounds (including hardpoint load) by the contact area to find the ground pressure. Then consult the table to find the vehicle's off-road speed:

Off-Road Speed: This is the fraction of top speed that the vehicle can reach when traveling off road. There are four categories. Record the speed for the appropriate motive system:

I: This category is used for walking vehicles, which are not covered here.

II: Use this for tracked vehicles.

III: Speed in the third category is used for vehicles with standard, heavy, or off-road wheels *with* all-wheel drive.

IV: The speed in the fourth category is used for vehicles with standard, heavy, or off-road wheels *without* all-wheel drive, or vehicles with skids.

Ground Pressure (GP) Table

Ground Pressure	*Description of GP*	*Off-Road Speed II*	*III*	*IV*
150 or less	extremely low	full	4/5	2/3
151-900	very low	4/5	2/3	1/2
901-1,800	low	2/3	1/2	1/3
1,801-2,700	moderate	1/2	1/3	1/4
2,701-7,500	high	1/3	1/4	1/6
7,501-15,000	very high	1/4	1/6	1/8
15,001 or more	extremely high	1/6	1/8	no

Vehicles with small wheels have no off-road speed. A fractional off-road speed is the best fraction of top speed the vehicle can reach when not moving on a road or a similar hard surface. "Full" means the vehicle operates at full speed off-road; "no" means it cannot move off-road.

Towing

A vehicle with wheels, tracks, or skids can be hitched behind and towed by any vehicle with a ground performance. Calculate the top speed, acceleration, and deceleration of the combination as if it were a new vehicle with the combined loaded weight of both vehicles and the motive system of the towing vehicle. gMR and gSR are based on the combined body volume of both, the motive system of the towing vehicle, and, if both vehicles have wheels, the combined number of wheels; gMR while towing cannot exceed 0.25 g. Ground pressure and off-road speed are calculated individually for each vehicle, and then the lowest off-road speed is used.

Aerial Performance

A vehicle with rotors can fly if its helicopter lift (in lbs.) equals or exceeds loaded weight.

Aerial Top Speed

Aerial top speed (aSpeed) is the top speed of the vehicle in the air. To find it, first calculate the vehicle's *aerial motive thrust* and *aerodynamic drag.*

Aerial Motive Thrust =
1.6 × motive power of helicopter drivetrain(s).

Aerodynamic Drag = [Sa/ Sl] + D, where:

Sa is the total surface area of the vehicle.

Sl depends on streamlining: 1 if none, 2 if fair, 3 if good.

D is the sum of: 10 for each person in an exposed seat, 15 for each person in a cycle seat or exposed standing room; 5 per loaded hardpoint the vehicle has (but only if calculating performance with hardpoints loaded).

Then use the aerodynamic drag and aerial motive thrust to determine the *aerial top speed* (in mph) using the following formula:

Top speed =
square root of [7,500 × (Amt/Adr)], where:

Amt is aerial motive thrust.

Adr is aerodynamic drag.

Round to the nearest 5 mph if over 20 mph, otherwise to the nearest mph. Due to limitations on rotor technology, if top speed exceeds 300 mph, reduce it to 300 mph.

Aerial Acceleration

Use the aerial motive thrust to calculate aerial acceleration (aAccel) in mph per second. The formula is:

aAccel = (Amt/Lwt) × 20.

Amt is total aerial motive thrust.

Lwt is the usual loaded weight in pounds.

Round to the nearest whole number.

Aerial Maneuver Rating

Aerial maneuver rating (aMR) is the maximum safe g (gravities) that the vehicle can pull in flight while turning or maneuvering.

If Vehicle has Wings or Rotors: aMR is calculated using this formula:

aMR = [(Whp + Rhp)/Lwt.] × TL × 30.

Whp is the sum of all wings' hit points. *Rhp* is the sum of all rotors' hit points.

Lwt. is loaded weight in pounds.

TL is the Tech Level of the rotors; use TL7 for most designs, or TL8 for very late TL7 designs. If vehicle has MMR rotors, treat it as one TL *lower.*

Aerial Stability Rating

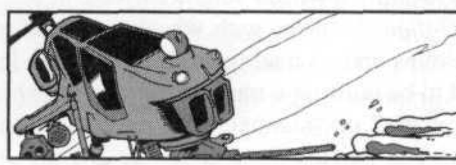
The aSR is based on the vehicle volume and various modifiers, and is calculated using the table below (minimum aSR is 1):

Aerial Stability Rating Table

Vehicle Has	*SR*
Volume under 99 cf	2
Volume 100-999 cf	3
Volume 1,000-9,999 cf	4
Volume 10,000-99,999 cf	5
Volume 100,000 cf or greater	6
Electronic controls	+1
Helicopter with TTR or MMR rotors	-1

Aerial Deceleration

The maximum aerial deceleration in mph/s (aDecel) is equal to the vehicle's aMR × 4.



Water Performance

Some ground vehicles and helicopters are designed to float, and a few are amphibious.

Floatation: A waterproof or sealed vehicle can float if it weighs less than 62.5 lbs. per cf of body volume. Pontoons add 37 lbs. of flotation per cf of pontoon volume.

This book does not contain detailed rules for water performance (refer to ***GURPS Vehicles***). However, a vehicle that can float may be able to swim (usually with a few minutes of work and some special kit attachments), using wheels, tracks, and/or small propellers attached to their drive shafts. To determine speed, use this formula:

Water Speed: If a vehicle can float and has a tracked or off-road wheeled motive system and drivetrain it can "swim." Calculate these values: *Aquatic motive thrust* is 2 lbs. of thrust per kW of tracked/wheeled drivetrain motive power, or 12 lbs. of thrust per kW of water drive motive power. *Hydrodynamic drag* is the (cube root of loaded weight) squared. Top speed (wSpeed) is 6 mph × [cube root of (aquatic motive thrust/hydrodynamic drag)].

As this formula is complex, GMs may simply assume that any amphibious vehicle can make about 4 mph in water, or 6 mph if it has a water drive.

Vehicle Operations 3

This chapter details how vehicles travel, maneuver, are maintained and repaired, and provides rules for using the equipment built into vehicles.

Vehicle Skills

These are the relevant vehicle operation skills for vehicles designed using ***GURPS Vehicles Lite:***

Driving (Automobile): Use this skill for vehicles moving on three or more wheels, whose weight does not exceed 10,000 lbs. Defaults to Heavy Wheeled at -2, other Driving skills at -4.

Driving (Construction Equipment): Required for operating vehicles that weigh 2 tons or more while using construction equipment such as bulldozers, plows, cranes, or the like. This includes farm tractors. Defaults to other Driving skills at -5.

Driving (Heavy Wheeled): Use this for vehicles moving on three or more wheels, with loaded weight of 10,000 lbs. or more. Defaults to Automobile at -2 and other Driving skills at -4.

Driving (Tracked): Use this for tracked vehicles. Defaults to other Driving skills at -4.

Motorcycle: Use this skill for powered one- or two-wheeled vehicles.

Piloting (Helicopter): Use this skill for all vehicles flying via helicopter drivetrains.

Routine Travel

Traveling from point A to point B uses the rules on pp. B187-188. Long trips in vehicles not designed for long-term occupancy (i.e., lacking bunks) result in fatigue: 1 fatigue per four hours if just serving as crew or passengers, double that if actually steering a vehicle, and four times that if driving off-road or piloting a helicopter at low altitude (below 500 feet). Also, double fatigue if any of these apply: occupants have no seats, cramped seats or spaces, or exposed spaces or seats in bad weather. Halve fatigue for roomy seats or spaces.

On the ground, GMs may require one vehicle operation (Driving, Motorcycling, or Piloting) skill roll per eight hours of travel on normal roads, per four hours of travel off-road or on bad or slippery roads or at night, or per two hours of travel in terrible weather conditions like blizzards or fog.

In the air, a roll is required on landing or takeoff, or per hour of travel at very low altitudes (under 500 feet) or per 10 minutes of flight below 100 feet in areas with tall buildings or power or telephone lines. Roll twice as often in bad weather. A roll should also be made when performing routine but somewhat dangerous maneuvers like acrobatics or a mid-air rendezvous.

GMs may wish to apply modifiers for very dangerous situations. However, only a critical failure results in any danger unless the operator's

Crew Actions and Crew Stations

A vehicle crew member can only operate controls or other vehicle systems assigned to his crew station. A character can move to a new crew station (provided no one else is occupying it) but this takes at least two seconds.

A single crew station may have many different functions assigned to it: weapons, electronic systems, vehicle controls, and so on. A character can only fire one weapon or set of linked weapons at once, regardless of how many weapons the crew station controls. However, this can be combined with maneuvering the vehicle or operating electronics such as sensors.

However, performing any "multitask" function is more difficult: the GM may wish to impose a skill penalty if a character tries to do too many things at once. Only count tasks that require attention: leaving a radio channel open does not, but an argument or vigorous discussion might count.

Looking in the direction one is driving or shooting doesn't count as a task, but attempting to spot hidden objects, visually or via sensors, or to maintain an "all-round" watch does. The suggested penalty for "multitasking" is -4 on skill for any "secondary" tasks that are not receiving the character's full attention – for instance, operating sensors or firing weapons while driving.

Fatigue is 3 or less – than any failure may result in danger. If a potential danger occurs, the GM should come up with a problem: ground vehicles may suffer collisions, get stuck, suffer flat tires, etc.; helicopters may hit the ground, collide with power lines, strike birds, and so on. Any vehicle could have a malfunction of some sort. Once the danger has been determined, allow a second vehicle operation roll to avoid it. A failed roll will usually only result in minor damage, but a critical failure brings a disaster. The effects will depend on the GM's whim, but may include a roll on the *Loss of Control* table, fire, or collision with a terrain feature, vehicle, building, or pedestrian.

Maneuvering

The following rules assume vehicles are being used on the standard ***GURPS*** hex map, with 1" equaling one yard.

When a vehicle enters combat, place its counter facing in the proper direction, then record its current speed (and elevation if appropriate). These statistics – along with accumulated G-force – are updated each turn.

The vehicle moves when its operator would begin his turn. His move, on most turns, consists simply of operating the vehicle. He may increase speed by up to the vehicle's Accel or *safely* decrease speed by Decel at this time (see *Extra Braking,* p. 43). After that, the vehicle must move 1 yard per 2 mph of current speed (round down). It must move straight forward unless it performs a bend maneuver (see below).

Aircraft may use a percentage of forward speed to change elevation instead. Each lost yard of forward movement raises or lowers the vehicle 1 yard. A turn must be spent at level elevation before switching from diving to climbing or vice versa. At the end of the turn, climbing decelerates and diving accelerates aircraft by 20 mph/s × (percent of speed devoted to climb or dive). This can allow an aircraft to exceed aSpeed.

Change of Top Speed

A vehicle's top speed can change, for instance when it moves off-road, or when damage occurs that lowers or eliminates its top speed. If the vehicle is presently moving faster than its new top speed, this has two effects: First, the vehicle may not accelerate above its new top speed. Second, the vehicle *must* decelerate each turn by *at least* 5 mph if on land or 1 mph if in the air. If the vehicle operator does not take action to decelerate, it will automatically decelerate by this amount.

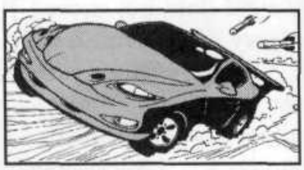
Turning (Bends)

To change its course, a vehicle must execute a bend maneuver (not called a turn, to avoid confusion with a one-second turn). A bend is measured in degrees. It pivots the vehicle right or left (pivot the counter from a rear corner).

Drifting across lanes in a highway is about 5°, followed by another 5° bend after the lane change.

Bends create *G-force.* A vehicle may execute any number of bends during its turn, but each additional bend is rated for its own G-force plus that of all previous bends in that turn. For instance, a 0.5-G bend following two 0.25-G bends would rate as a 1-G bend. At the start of each new turn, accumulated G-force drops back to 0.

A vehicle may safely execute bends with accumulated G-force up to its maneuver rating (MR). Each bend in excess of MR will require a *control roll* (see p. 43). The roll takes a penalty of -1 per 0.25 Gs by which the bend exceeds MR. Double this if MR is under 1, or quadruple it if MR is under 0.5.



Larger Scales

GMs may find it useful to use a larger scale for long-range battles. For example, 5 or 10 yards per hex means that each 10 or 20 mph of vehicle speed would translate into one hex/turn of movement.

Calculating G-Force

The G-force imposed by a bend equals (vehicle speed × bend degrees)/1,200, rounded to the nearest 0.25 G. Bends of more than 2 × MR cannot be attempted in realistic campaigns.

If bending in line with map hexes, a bend from facing a hex side to an adjacent hex point (or vice versa) is 30°, while from hex side to hex side is a 60° bend.

Each bend exceeding 3 G can cause vehicle occupants to gray out or black out. See p. CII131.

Riders and High Gs

Passengers on top of vehicles must make a ST roll for every bend exceeding 0.5 G. Apply a -2 at 1 G, -4 at 1.5 G, etc. Apply an additional -4 if the vehicle is performing a steep climb or dive, or a roll. Failure means they fall down; failure by 4 or more means they fall off. They automatically fall off if the vehicle operator fails a control roll.

Hazards

In addition to extreme maneuvering, various hazards can also force control rolls. These include *extra braking, obstacles,* and *taking damage*.

Universal Modifiers

The control rolls resulting from all hazards take an additional speed modifier of -1 for every 20 × MR the vehicle is moving, rounding down.

They also take a further -1 for every 0.25 G in bends by which the vehicle has exceeded its MR when it encounters this hazard (double this if MR is under 1, or quadruple it if under 0.5).

Extra Braking

As his turn begins, a vehicle operator may exceed the vehicle's Decel to slow it more rapidly. Ground vehicles may brake at up to 4 × Decel, others at 2 × Decel. This requires a control roll, at -1 per 5 mph/s by which the braking exceeds Decel, rounded down. Double the penalty if Decel is under 10 mph/s; quadruple it if Decel is under 5 mph/s.

Obstacles

A variety of potential pitfalls fall into this category, including potholes, air turbulence, telephone wires strung across the street, etc. Each particular one would have its own modifier, from +5 (a small dip in the road) to -5 (navigating a winding mountain road covered by an oil slick).

The Chicken Coop: Chicken coops, fruit stalls, etc. are always being hit by autos, at least in the movies. Driving through such an obstacle isn't a Hazard if the vehicle masses over 3 tons, but is a Hazard with no modifier to the control roll otherwise. More important, the cloud of scattered feathers (fruit, hay, torn newspaper, etc.) imposes a -2 Hazard on anyone following you!

Taking Damage

Sustaining crushing or explosive damage of 5 points or more per ton of vehicle weight creates a hazard. The modifier to the control roll depends on damage per ton *before subtracting DR:*

Damage Hazard Table

Damage per Ton	*Difficulty of Hazard*	*Damage per Ton*	*Difficulty of Hazard*
4 or less	No Hazard	50-99	-6
5-9	0	100-199	-8
10-19	-2	200-499	-10
20-49	-4	500 or more	-12

For instance, a 2-ton car that endures a cannon shot doing 60 points of damage would take (60/2 = 30) 30 points per ton, suffering -4 penalty hazard. If a collision caused the damage, a vehicle operator who deliberately caused or accepted the collision gets a +2 on the ensuing control roll.

Control Rolls

Each bend exceeding MR or hazard forces a vehicle operator to make a control roll. He rolls against the proper vehicle handling skill (Driving, Motorcycling, or Piloting) with the modifiers above. Additional modifiers are shown below:

Control Roll Modifiers

Ground (wheeled)	
Poorly maintained road	-1
Loose or gravel road	-1
Rain-slick road or runway	-2
Ice (on or off road) or packed snow	-3
Oil on road or runway	-3
Part or all of vehicle on shoulder of road	-1
Bad visibility	See below
Off-road, without off-road wheels	-2
Ground (tracked)	
Rain-slick road or runway	-1
Ice (off or on the road) or packed snow	-2
Oil on road or runway	-2
Bad visibility	See below
Air	
High winds	-1 to -2*
Major storm	-4*
Bad Visibility	See p. 51 **
Visibility Control Roll Modifiers	
At night, area well-lit	-2*
At night, poorly lit back streets	-4*
At night, open country or unlit street	-6*
Total darkness	-10*
Rain or mist	-1**
Heavy rain or light snow	-2**
Driving through smoke screen	-3**
Dense fog or blizzard	-4**

* Ignore if using headlights, Night Vision (including Light Amplification), radar, infrared, or thermal imaging.

** Ignore if using radar; halve if using infrared or thermal imaging.

Air Modifiers: Double the penalties when flying within 100 yards (300') of the ground. Vision penalties apply only if the aircraft is flying at or below that altitude, or close to another aircraft.

Failing a Control Roll

If a control roll fails, subtract the vehicle's Stability Rating (SR) from the amount by which the roll was missed, and consult the appropriate table below. Treat a critical failure as having missed by at least 10, unless it was worse!

The operator spends his next turn fighting to regain control; he cannot maneuver (which may lead to him crashing into something that he can't avoid). Gunners lose any aiming bonuses and suffer a -1 penalty per point by which the control roll failed until the operator regains control. Any standing occupants make a DX roll at the same penalty to stay upright. If they could conceivably fall out, they make another DX roll, at no penalty, to avoid doing so.

If multiple failures occur, only the worst result remains in effect at any one time. For instance, a car that is skidding and then fails another roll and suffers a vault result quits skidding and begins the vault.

Ground Loss of Control

Failure	*Result*
0 or less	Skid if caused by bend, otherwise Veer
1 or 2	Spinout*
3 or 4	Roll
5 or more	Vault

* If vehicle has 1 or 2 wheels, treat as a roll.

Skid: The vehicle immediately moves 5 yards in the direction it was moving *before* the bend. Subtract 10 mph from current speed. Tracked vehicles must make a HT+2 roll or shed a track.

Veer: The vehicle changes facing by 30°: roll randomly to see if it turns right or left. Tracked vehicles must make a HT+1 roll or shed a track.

Spinout: Any wheels or tires take 1d damage each per 20 mph of speed (round up). Tracked vehicles must make a HT-2 roll or shed a track. The vehicle starts to spin. It continues to spin in the same direction throughout the spin, but rotates 60° per 5 yards of movement, in the same direction if the spin resulted from a bend maneuver, or a random direction if from a hazard. The driver cannot maneuver, voluntarily accelerate, or decelerate. Each turn the vehicle spins, it decelerates by 20 mph. The driver can try to may attempt a control roll at -4 as each turn begins; success ends the spin and points the vehicle back toward the original facing.

Roll: The vehicle turns 90° sideways and rolls in the direction it was facing before it turned. Each yard of rolling movement counts as 2 yards of ordinary movement. At the end of any rolling turn, the body and every subassembly attached to its top, underside, right, and left takes 10d damage per ton of loaded weight. Anyone strapped into cycle seats also take this amount of damage; anyone in a cycle seat or riding outside the vehicle and not strapped in is thrown out of the vehicle. It decelerates at 20 mph per turn and cannot be controlled until it stops rolling. Then roll 1d: on a 1-3, the vehicle is right side up and is once again drivable, otherwise it has overturned and must be righted before driving. Vehicles with two or fewer wheels never end right side up, and the vehicle must be physically lifted back into place.

Vault: The vehicle leaps skyward, sails 1d vehicle lengths, then crashes into the ground. Treat damage as a head-on collision with the ground to a random body side (1-2 = front, 3 = right, 4 = left, 5 = back, 6 = top). The vehicle then spins along the ground on the same side that took damage, unless this was the front or back, in which case roll randomly (1-2 = left, 3-4 = top, 5-6 = right). Treat this as a sideswipe collision (p. 47) with the ground, at the vehicle's former speed. Finally, the vehicle skids to a stop – still on its top or side – a further 1d vehicle lengths away.

Track Loss: If a tracked vehicle sheds a track, gSpeed is zero until the track can be reattached. It can be repaired with a Mechanic roll and one man-hour's work per four tons of vehicle mass.

Whiplash: If a vehicle rolls or vaults, all occupants suffer whiplash – see p. 47.

Aerial Loss of Control

Failure	*Result*
0 or less	Energy Loss if caused by bend, Veer otherwise
1 or 2	Severe Energy Loss if caused by bend, Veer and Energy Loss otherwise
3 or 4	Tailspin
5 or more	Disaster

Energy Loss: The vehicle loses 5 yards of altitude and decelerates by 5 mph per 0.25 G of bend or other maneuver that was attempted.

Veer: The vehicle veers 30° to right or left; roll randomly.

Severe Energy Loss: Same as *Energy Loss*, but double effect. There is a 1 in 6 chance that any propulsion system that uses fuel may stop working – treat as disabled until it can be restarted, which requires a Piloting-4 roll each turn. A rotor loses 1d-1 × 10% of its original hit points due to rotor strain!

Tailspin. The vehicle spirals down out of control. It must use 100% of its speed to dive each turn. Each turn, it will roll 180° and change facing 30° in the direction of its present maneuver, and any rotors lose 2d-2 × 10% of their original hit points. Each turn, the pilot can try to pull out: this requires a successful control roll at -5, plus all hazard modifiers that apply.

Disaster. The rotor fails, etc. As per tailspin, but no chance of recovery.

Loss of Operator

If a vehicle's operator is knocked out of action in any fashion, a ground vehicle with fewer than three wheels will go into a roll. Other vehicles treat loss of an operator as an automatic hazard rolling 1d+2, subtracting SR, and consulting the appropriate table.

If the vehicle is still moving afterward, vehicles decelerate by 5 mph per turn, and helicopters also lose 5 yards of altitude per second until they crash.

Special Movement Rules

The following special circumstances fall outside the normal movement rules:

Moving in Reverse

A ground vehicle at 0 mph speed can shift into reverse. (Wheeled vehicles can only reverse if they have at least 3 wheels.) A vehicle in reverse has a top speed of 20 mph or half its normal top speed, whichever is less. It can accelerate at half normal rate. To shift to forward movement, it must decelerate back to 0 speed. All control rolls while in reverse are at -4.

Terrain and Off-Road Movement

Ground vehicles have an off-road speed. Use this fraction of top ground speed when the vehicle is off-road. Some terrain further slows the vehicle:

Broken: Rocky or very hilly terrain, broken up by gullies and ridges. It may be barren or covered with vegetation. A vehicle uses half its off-road speed.

Forest: Terrain with thick vegetation – dense hedgerows, jungle, or thick woods. Vehicles with a Size Modifier of +2 or less move at normal off-road speed, others at half off-road speed. Helicopters will be unable to land unless they find a large clearing. *Exception:* A vehicle massing 50 tons or more with no rotors or wings *and* front body DR 50+ can crash at normal off-road speed.

Quagmire: Mud, swamp, riverbanks, marsh, very soft sand, and deep snow. Off-road speed is halved in quagmire unless the vehicle has extremely low ground pressure. A vehicle with high to extremely high ground pressure may get stuck – make a Driving-4 roll every 10 minutes (if high ground pressure), 1 minute (if very high), or 10 seconds (if extremely high) to avoid this. If stuck, it cannot move. Extricating a stuck vehicle requires reversing, and takes a skill roll at an additional -5. One attempt may be made every three seconds; failure by 5+ means it's permanently stuck, until towed out.

Snow-covered or Ice: Any road or terrain can be described as "snow-covered" or "icy." Vehicles move at 2/3 road or off-road speed.

Slopes

Uphill slopes decelerate ground vehicles; downhill slopes accelerate them. Both add 1 mph/s per 4.5° of slope to Accel or Decel; this does not count against a vehicle's own gAccel or gDecel, which can be used to offset or increase a slope's effect. Either sort may increase the vehicle's speed beyond its normal forward or reverse top speed.

A slope too steep to scale is not a slope – it's an obstacle! A vehicle can scale a vertical obstacle whose height in feet is less than (vehicle Size

Action Without a Map

The maneuvering rules can be used without a hex map, whether the advanced or basic combat system is being used. For instance, if a pedestrian blunders in front of a PC's car, it's fine to simply tell the player "Make an IQ roll to spot him. O.K., now you need to make a 90° bend to avoid hitting him – do you want to risk it? Make the Driving roll," and then use the rules and the amount the PC made his roll by to judge success.

For instance, if the driver barely made his roll, he avoided the pedestrian, but may have veered into other traffic, requiring further rolls to avoid difficulty. If he failed, the vehicle skidded before turning, and the PC ran the pedestrian over; and if the driver rolled a critical miss . . . it's time to consult the *Loss of Control* table!

This is the easiest way to quickly handle what happens if a party of foot soldiers are suddenly confronted by a main battle tank on the horizon. Keep track of vehicle movement and spatial relationships with pencil and paper or in the GM's head, but use normal rules. GMs will need to carefully describe cover, terrain, and so on, and describe, using dramatic license, what happens if someone fails a control roll: "You suffered a six-yard skid? The Corvette jumps the curb and crashes into the hot dog stand. The owner throws himself aside as your car totals his cart, ketchup and hot dogs flying everywhere!"

Modifier + 1) × 1 foot for tracks, 0.5 for off-road wheels, or 0.25 for other wheels. Climbing an obstacle is a +0 Hazard. A vehicle which hits an obstacle it cannot scale collides with it (p. 47) instead.

Stunts

These are special maneuvers a vehicle can perform. A "stunt" is much like a bend or drift, but it differs in that a control roll is always required whether or not *G* exceeds MR, and the results of failure are usually greater than normal.

Bootlegger Reverse

A bootlegger is a controlled skid to reverse the vehicle's direction, effectively turning 180° and decelerating to 0. It can only be performed by a four (or more) wheeled vehicle, or a cycle-sized (50 cf or less) two-wheeled vehicle with a cycle-seated driver (he uses his foot to control the skid).

The driver may not accelerate or decelerate on the turn he attempts a bootlegger, and the vehicle's speed may not exceed twice its gDecel in mph/s. No other actions can be performed – including maneuvers and firing. To perform a bootlegger, treat it exactly like a 90° bend, but a control roll is automatically required, and made at -1 to skill. Success means the vehicle does *not* continue to move in the direction it is now facing. Instead, its next five yards of movement are a controlled skid in the direction it was going before it made the turn. It then it rotates 90° and decelerates to 0 speed, ending the turn facing the direction it originally came from. Failing a control roll has normal effects.

Whether the vehicle succeeds or fails, it takes 3d damage to each tire (or to its wheels, if no tires), although this does not count as a hazard unless any of the tires or wheels are destroyed.

T-Stop

A T-stop is a controlled skid that suddenly halts the vehicle. Use the same rules and constraints as a bootlegger, above, except treat as a 90° bend. Instead of reversing direction, if the control roll succeeds, the vehicle turns 90° as planned, and also decelerates to 0 speed. Failing the control roll for a T-stop has normal effects. Whether the T-stop succeeds or fails, the tires (or wheels) also take damage as per a bootlegger.

Helicopter Agility

Each turn, helicopters may trade 2 mph/s of aAccel to change altitude by 1 yard, or drift 1 yard left or right while keeping the same facing; 5 mph/s of aAccel can be traded for a one-turn +0.25 aMR.

A hovering helicopter may switch to sideways or reverse movement, at one-half its usual aMR and aAccel. Its sideways or reverse speed may not exceed half its top speed or 150 mph, whichever is less.

Auto-Rotation

A helicopter that loses power to its rotors may avoid falling out of the sky by auto-rotating, using the helicopter's controlled descent to spin its rotors to provide sufficient lift to prevent catastrophe. To successfully auto-rotate to a safe landing, the pilot must make a successful control roll (treat as a hazard with no difficulty modifier). Failure means he cannot recover control, and the helicopter will fall. If he succeeds, the helicopter auto-rotates down to a safe landing.

Dusting

A helicopter's rotors stir up dust and debris below it. The radius of this effect is equivalent to the linear dimension of the helicopter's Size Modifier. In the area immediately below a helicopter (the helicopter must be hovering at less than 10 yards altitude), the wash from its rotors disperses smoke screens and dust clouds, blows papers and hats around, etc. Anyone in the open trying to concentrate on anything (firing weapons, etc.) will be at -1 on skill.

Falling

When a large object like a vehicle is falling through an atmosphere, powered only by gravity, its speed increases as it falls to the ground. Assume an object's falling speed will increase by 20 mph per second until it reaches terminal velocity, after which it will continue to fall at that speed.

To find terminal velocity, calculate the speed of the vehicle using the aerial top speed rules but with an aerial motive thrust of one pound per pound of vehicle loaded weight, due to gravity. When a vehicle falls to the ground, treat it as if it had a collision (angle as appropriate) with the ground (or whatever else it hits!) at a speed based on its current speed.

Leaping or Falling from a Vehicle

If a character does this, calculate falling damage normally, and then add 1d damage for every 5 mph of speed.

Collisions

Collisions happen automatically when a vehicle's course intersects another object or the ground. Any colliding object (vehicles, people, etc.) inflicts a basic collision damage of (body HP/200) dice of crushing damage. Armor DR protects, but see *Whiplash*, below.

Head On: This occurs if two moving vehicles strike while traveling in opposite directions, or within 30° of being opposite. Multiply basic collision damage by the sum of the vehicles' speeds. Damage is usually to the front of both vehicles, unless one was moving in reverse or sideways.

Rear End: This occurs if two moving vehicles collide while traveling in the same direction, or within 30° of the same direction. Multiply basic damage by the faster vehicle's speed minus the slower vehicle. Damage is usually to the front of the faster vehicle and back of the slower. The slower cannot inflict more damage than the faster!

T-Bone: This occurs if the relative direction of movement is not within 30° of either the same or the opposite direction. Multiply basic damage by the striking vehicle's speed. Damage is usually to the front of the striking vehicle and the side hit (right, left, top, or underside) of the struck object. The struck object cannot inflict more damage than the striking vehicle inflicts. *Collisions with stationary objects such as buildings (or, usually, pedestrians) are T-bones.*

Sideswipe: This occurs if two objects would normally pass one another (either moving in the same or opposite directions) but one bends, skids or changes elevation into a collision while side by side with the other. Calculate damage as for a head-on (if in opposite directions) or rear-end (if in the same direction) collision, then divide by 4, rounding down. Damage is usually to left or right sides, but could be to top and underside in an aerial "sideswipe."

Bulldozer Blades: If the striking vehicle has a bulldozer blade, it adds +1 per 2 dice in any head-on, T-bone, or rear-end collision. If a bulldozer blade-equipped vehicle is involved in a head-on collision, it takes one less point of damage per 2 dice.

Collisions with Immovable Objects: If a vehicle hits the ground, a hill, or similar object, it inflicts *and receives* its own basic collision damage times its own speed. Reduce damage by -2 per die for collisions with water or -1 per die for collisions with snow, soft mud, etc.

Dodging a Collision

Normally, a collision is automatic but if one of the objects is much larger (its Size Modifier is 3 higher than that of the other) the smaller object can dodge, provided it (or its vehicle operator) is aware of the incoming object and free to move. Dodging is also possible in mid-air collisions, regardless of vehicle size. Make a normal Dodge roll, though PD doesn't help.

Collision Aftermath

After assessing damage, if the vehicle inflicts at least twice as much damage as it receives, it knocks the other object aside, its speed is not changed; the other object is pushed aside and takes a -4 to any hazard control roll.

An *overrun* takes place if the vehicle's body Size Modifier is 3 or more higher than the struck object's. Overruns don't push the other object aside – they go over it, doing additional damage (to its top, if a vehicle) of 1d per ton of weight (round down). The overrunning vehicle suffers no hazard.

Otherwise, effects are:

Head On: Both of the vehicles come to a complete stop.

Rear End: Both take on the average of their previous speeds.

T-Bone: Both vehicles have their speeds halved, unless the striking object inflicts less than 1/20 of the struck object's base body HPs, in which case the struck object's speed is unaffected and the other is knocked aside as above.

Sideswipe: None, other than damage and potential hazard.

Vehicles now check for a hazard based on collision damage received, unless they performed an overrun.

Whiplash

People take 1d-2 damage per 20 mph of speed change that results from a collision; double damage if not wearing a seat belt! For example, if a car crashed into a hillside and went from 50 to 0 mph as a result, the whiplash would do 2d-4 crushing damage, or 4d-8 to anyone without a seat belt. Only Toughness and airbags provide DR.

Airbags: If a person in a seat with an airbag suffers a crash at a collision speed of more than 20 mph, the airbag instantly inflates, doing 1d-3 crushing damage to the occupant. However, the airbag provides DR 7 vs. any whiplash and concussion damage. An activated airbag impedes vision and blocks movement (make a DX-2 roll each turn to get loose; until loose, you can't operate vehicular equipment). Airbags only work once; replacements cost $50.

The Narrow Passage

Sometimes, vehicles of any type may have to negotiate a very narrow passage. This can be used for flying through tunnels, driving between other vehicles, and the like.

The GM should select a Size Modifier for the tunnel or passage based on how wide it is. A vehicle that has an equal or larger Size Modifier cannot fit through it. One with a smaller Size Modifier can, but it will be a tight fit. If a vehicle has wings or rotors, add 1 to its effective Size Modifier.

Make a Hazard control roll. Normal penalties for speed apply. In addition, there is a penalty based on the difference between the vehicle's Size Modifier and the passage's:

Vehicle is 1 smaller	-4
Vehicle is 2 smaller	-2
Vehicle is 3 smaller	no modifier
Vehicle is 4 or more smaller	no roll needed

Only one roll is normally needed. An additional roll should be required every minute or so, or whenever the vehicle makes a Dodge. Any Veer result leads to a sideswipe collision with whatever the vehicle is passing through (tunnel walls, other vehicles, etc.). Other results cause the usual effects (Roll, Spin, etc.), plus a head-on collision with the object.

Hitting Buildings

Treat as a T-bone collision. See p. B125 for wall DR and hit points. If a vehicle fails to crash through a wall, it stops. Even if it does, it may be slowed: it decelerates by [(HP + DR of barrier)/damage rolled] precrash speed in mph, rounded to the nearest half or whole number.

Using Vehicle Systems

These rules describe how to use miscellaneous equipment, instruments, and electronics.

Communicators

Radios can send code or voice, and – in conjunction with a computer terminal – text, video, or data transmissions. They are broadcast systems, and anyone with a radio tuned to the proper frequency can listen in on a radio signal; transmissions can also be jammed. Range can be extended on a successful Electronics Operation (Communications) roll, at -1 per extra 10% added to range, to a maximum extension of 100%.

Scramblers: A communicator equipped with a scrambler system sends frequency-agile transmissions. If sender and receiver use scramblers with the same settings, a message will be gibberish to anyone else listening in.

Datalink: This enables a computer link to be established by communicator with another electronic device, such as a radar or computer, displaying its data on its screen, using its information for targeting purposes, etc. Datalink allows several computers on different vehicles to share sensor, targeting and navigation information. Also, text communications are less likely to be misunderstood in the confusion of battle.

Vision Systems

Light Amplification: This gives a person looking through it effective but color-blind Night Vision as per the advantage (p. B22).

Low-Light TV (LLTV): This is a TV camera with telescopic optics that is downlinked to a view screen inside the vehicle. It magnifies distant objects like a telescope, but incorporates a light amplification system as well.

Searchlights: These project a bright beam of visible light illuminating a 2-yard radius per mile of range. The beam can be spotted at twice its range. A searchlight can blind someone looking at it (as long as the search light is facing him) for 1d seconds on a failed HT roll. This is a ranged attack; a roll to hit (give the light SS 20 and Accuracy 15) is required each turn.

Telescope: This makes distant objects seem closer; a 10× scope, for example, makes an object seem one-tenth as far away.

Mast-Mounted Sights

Sensors so equipped are mounted atop a helicopter's rotors; a helicopter need only expose these to see over a hill or building.

Using Sensors

Radar and thermographs are the most common sensor systems used on vehicles. Both are effective by day or night, at ranges beyond ordinary human vision. They cannot see over the visual horizon, but can penetrate darkness and normal smoke or fog. They do not work underwater.

The GM can require an Electronics Operation (Sensor) skill roll to locate a specific targets, or to distinguish (for example) a vehicle concealed among buildings, or to tell a commercial vehicle from a military one at beyond visual range. Add a vehicle's Size Modifier to any rolls to detect it.

Radar

Detects objects out to the listed range as "blips" on a screen, although their exact shape (unless its the size of a large building) is usually a mystery. Radar is an active sensor – its beam can be detected by radar detector systems. Radar may be optimized for air search or surface search:

Surface Search: -5 to detect targets silhouetted against the sky or space.

Air Search: -5 to detect any target silhouetted against ground or water.

Targeting radar also gives a bonus in combat; see *Targeting Systems,* below.

Imaging radar provides a low-res but distinct silhouette of the object, enough to (for example) distinguish an MBT from a passenger car.

Infrared

Infrared Searchlight: Detects objects illuminated by the searchlight's beam by day or night, as per the Infravision advantage (p. B237), out to the listed range. Anyone with infrared vision or thermograph sensors can detect the infrared searchlight beam out to twice the searchlight's normal range, however.

Thermograph: This is an advanced high-resolution infrared sensor. It provides a television-style visual image. Treat a thermograph as Infravision (p. B237) but with no -1 penalty for night combat and an extra +1 to Tracking bonus.

Using Navigation Systems

Navigation Instruments: These permit navigation out of sight of familiar landmarks through the use of charts and instruments. +4 to skill when using dead reckoning, and with radio assistance they are accurate to within 100 yards.

Autopilot: A device that, once set, keeps a watercraft or aircraft on a steady course at a constant speed. It is impractical on land vehicles. Adds +1 bonus if used in conjunction with INS or GPS.

Transponder: A continuous radio beacon that allows air traffic control systems (and the military) to track and identify the vehicle. Used by civilian aircraft.

Inertial Navigation System (INS): +5 to Navigation skill; effectively gives the vehicle operator the Absolute Direction advantage (p. B19) while using it.

Global Positioning System (GPS): Effects are similar to INS (but not cumulative with it). Accuracy is to about 10-25 yards for civilian systems, 5 yards for military systems. Prior to 2000, users of U.S. NAVSTAR system who did not have access to the encrypted GPS channel were limited to an accuracy of about 80-100 yards. GPS receivers can store the coordinates of a location it has visited (called a "way point"). It can then later direct the user to that way point or (if the vehicle's communication systems have digital datalink) transmit that waypoint data to other GPS systems.

Surveillance Systems

Recon or Movie Camera: A telephoto camera is designed to film automatically once activated (make only one Photography roll; anything but a critical failure means it's not professional quality, but the picture is still taken). Images taken by a moving camera will be blurred unless it has stabilization. This version is a professional 35mm broadcast or motion picture model, capable of producing very sharp images from high altitudes.

Targeting Systems

Laser Rangefinder: +2 to weapon Accuracy when aiming at an object in line-of-sight and within the laser rangefinder's range. It can only be used to aim at one object per turn. Laser rangefinders (and designators, below) can't penetrate smoke, thick fog, snowstorms, or water. The beam is invisible.

Laser Designator: Used to illuminate a single target at a time to guide SALH missiles or laser-guided bombs (p. 12). To illuminate a target, the designator must be within range and line-of-sight of the target, and the operator must take continuous Aim maneuvers until the munitions hit.

Dedicated Targeting Computer: Gives a +3 bonus to Gunner skill with a weapon or set of linked weapons. Computer is hardened against electromagnetic pulse from a nuclear detonation.

Targeting Radar: A radar (except one with the "No Targeting" option) can be used to "target" objects, providing a +2 bonus to hit with vehicle-mounted weapons. This bonus is not cumulative with that for laser rangefinders.

HUDWAC and Pupil Scanner: Reduces gunner's SS number; see p. 15.

Electronic Countermeasures

Radar Detector: Warns the user of radar emissions, usually with a tone. It can detect an operating radar that is in line of sight (i.e., not behind a hill or over the horizon), and emitting in the vehicle's direction, at out to twice the radar's range.

Advanced Radar Detector: As above, but also gives range and bearing to the radar, and can also inform the user if radar is operating in targeting mode (providing bonus to hit or guiding missiles).

Laser Sensor: Warns the user if a laser rangefinder or designator is currently being aimed at the vehicle.

Infrared Jammer: Emits thermal radiation to distract and confuse infrared homing (IRH) missiles. It has no effect on sensors. Subtract the jammer rating from attempts by an IRH missile to lock onto the vehicle.

Dischargers

A multibarreled launcher for specialized projectiles such as smoke bombs or flares. Each discharger holds one salvo of decoys or smoke grenades; vehicles sometimes mount multiple dischargers. A radar or laser detector can be set to automatically trigger a discharger. Dischargers on aircraft fire behind and below the craft, while those on a ground vehicle fire upward at a point about 20 yards in front of the direction they face. There are several "decoy" loads that can be loaded into and launched from a standard discharger.

Flares are used to jam infrared-homing missiles (p. 16). *Smoke* is used to create a thick smoke screen (p. 16). *Hot Smoke* is also effective against infrared and thermographs (p. 16). *Prism* is a cloud of laser-reflecting crystals, jamming laser designators and rangefinders. The "burst radius," or radius of the area of effect, is about 100 yards for chaff, and 20 yards for other types.

Any or all of a vehicle's dischargers may be fired per turn. Firing a discharger is not a combat maneuver; it can be combined with Dodging. If a crew station controls multiple types of discharger, it may use one of each in a single turn.

Construction Equipment

Extendable ladder: This is a ladder of the sort used by fire-fighting vehicles; see p. B89.

Crane: Used to elevate and move heavy loads. Using the crane requires one person to operate it (this may be the vehicle's driver, if he isn't driving the vehicle at the time) and is a long action; roll vs. Professional Skill (Crane Operation) to perform delicate tasks, grab people, etc.

Winch: A revolving-drum towing device with attached harness or hook, normally installed next to a door or over a floor hatch. A built-in motor draws the cable back to the reel, allowing the vehicle to pull something that weighs less than it toward it, or to pull itself toward the object, if the object is immobile or heavier than the vehicle. Winches are rated for their lifting capacity in pounds. Winch speed is four yards per turn (half speed if pulling more than half its maximum weight). If towing something horizontally across a smooth, level surface, halve the effective weight, or divide effective weight by 20 if the object has wheels (e.g., if towing a car or trailer). Multiple winches may also be used to lift very heavy objects.

Power Shovel: A powered scoop or shovel designed for digging and moving earth. It can dig and move earth like a man with a shovel and pick with its rated ST (see pp. B90-91). Digging requires the attention of the operator (usually the driver). He cannot fire weapons or maneuver while operating the shovel.

Miscellaneous Equipment

Stretcher Pallet: A stretcher-bed for one person, equipped with safety straps and suitable for use in an ambulance or medivac aircraft.

Emergency Lights and Siren: A siren and flashing light, as used by police cars, ambulances, fire engines, etc. It is useful for clearing the road (when operating, it adds +4 to Vision rolls and +8 to Hearing rolls to detect the vehicle). Turning the lights and siren on or off is a combat action.

Security and Dirty Tricks Equipment

Burglar Alarm: An electronic burglar alarm sets off a siren and locks the vehicle's ignition system if the vehicle's locks are tampered with. Breaking into a vehicle without setting off the alarm requires a Contest of Skills vs. the alarm's skill of 15, using Electronics Operation (Security System) or Traps, with modifiers as per Lockpicking skill (p. B67). If the roll fails, the alarm sounds a siren and/or flashes the vehicle's lights. An alarm may also lock the vehicle's ignition systems and other controls, or send a signal to a pager or radio carried by the owner.

Mutable License Plate: A set of license plates can change its designation at the touch of a button: it rotates, revealing a new side.

Oil Spray: This produces a 5 yd. × 2 yd. oil slick behind a vehicle. Driving into the slick requires a Driving roll at -3 (as a Hazard) to avoid losing control. It contains enough oil for 25 slicks and costs $5 to refill.

Smokescreen: This produces a 5 yd. × 2 yd. cloud of smoke. Anyone firing through the smoke suffers the normal penalties for blind fire unless using non-visual imaging or active sensors like infrared or radar. The screen remains in the air for 300 seconds/wind speed in mph (maximum 300 seconds). A smokescreen has 10 shots and costs $25 to refill. In vehicles with diesel engines, this component generates a smoke screen by injecting fuel into the exhaust; this uses 1 gallon of fuel for every 6 shots.

Spikedropper: This drops caltrops – tetrahedral spikes – behind a vehicle. The caltrops cover a 2×2-yard area. Any tracked, legged, or wheeled vehicle driving through the area may be damaged. Roll 1d for each track, tire, or leg. On a 1-4 it takes 2d damage to the motive subassembly (wheels take damage to tires). A spikedropper has enough spikes for 10 uses; refills cost $200.

Environmental Systems

Environmental Control: A basic light, heat, air-conditioning, and ventilation system, this improves quality of life and allows occupants to operate at external temperatures up to 120° F or down to -30° F without penalty; treat higher or lower temperatures as if 40° closer to optimum.

NBC (Nuclear-Biological-Chemical) Kit: This consists of sensors to detect contaminants, plus filters and an overpressure system (the interior is kept at higher air pressure than outside) to keep impure air out. It defends against nuclear fallout, germs, or chemicals such as pollution or poison gas. Only people entirely inside the vehicle benefit from an NBC kit. The vehicle must be sealed. Filters must be changed periodically (depending on the type of contamination, but usually at least once every 2 days) at a cost of 1% of the system cost. Spare filters have 5% of the system's weight and volume.

Visibility and Windows

Vehicles have poor, fair, or good vision (p. 36).

"Good" means a wide field of view – also that shots can easily hit a poorly armored canopy, windscreen, or window! This is typical of autos and airplane cockpits. Any "window" critical hit will ignore some or all of the vehicle's armor.

"Fair" allows the operator to see forward and to the sides, but the view backward requires an external mirror. The GM can impose -1 on Vision rolls to spot things, especially if they are on the edge of the field of view. If a "window" critical hit is rolled and the occupant would be hit, roll 1d. On a 1-3, vehicle DR protects the occupant.

"Poor" provides a tiny porthole, vision slit, viewing block, etc., or has no view at all. The vehicle operator can only see forward. Occupants can't be hit by "window" critical hits, but all Vision rolls are made at a -2 or worse penalty. People right next to or standing on the vehicle can easily move out of the occupants' field of view.

Vision can always be improved by opening a door or hatch and peering out, but this leaves the crewman vulnerable to attacks. Even so, a tank commander will often ride with the top hatch "unbuttoned" for a good view.

Crew stations with visual augmentation systems (low-light TV, etc.), thermograph, or imaging radar sensors can avoid the penalties for fair, poor, or no view by using them. In the event that a window critical hit does occur and a canopy, window, or the like is actually hit, it has one-half the PD and DR of the location they look out of, rounding down, to a maximum DR 15. If a window is rolled down or a canopy is open, it provides no DR.

Maintenance and Repairs

A vehicle needs routine maintenance after being used for a period equal to its Maintenance Interval (MI). This involves changing the oil, putting on new belts, etc. It takes 4 hours and a tool kit or workshop. If maintenance is missed, roll against the average Mechanic skill of those who last performed this routine maintenance, at -4 per additional checkup missed after the first.

If that roll fails, roll vs. the vehicle's HT. Failure means HT drops by 1. Repairing lost HT is a minor repair (see below). A critical failure has the same effect, but it also means a serious breakdown. The GM picks the malfunction's type and timing (engine trouble, broken axle, etc.).

Ground Vehicle Breakdowns

A *powered* ground vehicle that (a) doesn't use wheels, (b) has HT less than 10, or (c) has a racing engine, must make a HT roll for every six hours of continuous travel, or for every half-hour of travel if it has a racing engine. Wheeled vehicles add +5 to this roll, tracked vehicles +2.

If a roll fails, the drivetrain or suspension system has malfunctioned. Repairs will require 1d man-hours and a Mechanic roll. On a critical failure, the motive subassembly or drivetrain loses all its hit points and is effectively disabled until repaired. Also, the GM may rule that an accident of some sort takes place.

Repairing Damaged Vehicles

Fixing a vehicle part (body, subassembly, or component) with some hit points remaining is usually a minor repair. Roll against the appropriate Mechanic skill for each half-hour of work. Success restores 1 lost hit point times the amount the roll succeeded by (minimum 1 hit). All normal modifiers for using the skill apply.

If the item has no hit points left, fixing it is a major repair. These work exactly like minor repairs, except they take a -2 penalty. The GM may require spare parts, at 10%-60% of original cost.

VEHICLE COMBAT 4

This chapter describes how the ***GURPS*** combat rules handle attacks made by or against vehicles. For ramming, see the *Vehicle Operations* chapter.

FIRING VEHICULAR WEAPONS

Vehicle gunners take their turns normally, unless movement penalties prohibit them from firing. They may take the Wait maneuver to fire later, even in the middle of their vehicle's move.

Vehicle gunners may aim while firing and take no Recoil penalty. Unless provided with special mounts (p. 24-25), vehicular weapons can only fire within 15 degrees of straight out from their facing; however, a turret (or rotating open mount) and its weapons may vary their facing independently from the body.

Normal vehicle weapons use direct fire, and are limited to attacks on targets that can be seen by the gunner, not hidden by intervening terrain or objects nor over the horizon. This usually limits its range to under 5,000 yards, if both firer and target are on the ground or flying just above it.

Indirect fire is possible at greater ranges and for targets outside line of sight if performed by vehicles with weapons in high angle or universal mounts with the assistance of a forward observer. Mortars may *only* fire indirectly. See p. CII60. Do not apply the indirect fire range multiple; this is already included in the maximum ranges listed for mortars, guns, etc.

Very High RoF

Some weapons have rates of fire of 20 or more, up to RoF 100 for miniguns and Gatlings! For identical, linked automatic weapons with a single or combined RoF of 20 or more, resolve fire using 20-round groups instead of normal 4-round groups, using the table below:

Roll Made By	*-3*	*-2*	*-1*	*0-1*	*2-4*	*5+*
Number of Hits	0	1	5	10	15	20

Thus if the roll needed to hit is 14, and a 12 is rolled, 15 rounds hit the target. If the RoF does not divide evenly by 20, either ignore the excess or calculate fire for it in groups of 4 (see p. B120).

If the target gets a PD or Dodge roll, this can also be simplified. Rather than rolling Defense against each shot, make one roll that applies to all shots in the entire 20-shot group.

Scattering

Attacks with CHEM or explosive warheads that miss or were dodged will land *somewhere* and do damage. Look up the amount that the attack missed by on the *Size and Speed/Range Table* (p. B201). The value in the Linear Measurement column indicates how far away the attack landed, with a minimum of 1 yard and a maximum of 10% of the range to the target. Determine direction of miss as per grenades (see *Scatter,* p. B119).

USING GUIDED MISSILES

Modern combat vehicles often carry guided missiles, which use special rules. If successfully launched (see below), missiles take (range to target/missile Speed) turns to reach a target. Modify this if the target is closing or running; e.g., if the target is attempting to flee, it takes (range/missile's Speed advantage).

Once launched, the missile moves toward the target, bending up to 30° each turn to keep on course, until line of sight is broken, maximum range is reached, or it hits. The missile can fly for a number of turns equal to its endurance. If the missile can successfully catch up with and intercept its target, it hits automatically (unless dodged).

Operator-Guided Missiles

These are wire- or radio-guided missiles that are steered toward a target by the gunner. The firer makes a Gunner+4 roll to launch the missile; failure means it crashes. The firer must keep the target in sight, the weapon in wire (WG) or radio (RG) contact, and make an unmodified Gunner roll for each turn of flight for early TL7 (MCLOS) systems or each five turns or fraction for later TL7 (SACLOS) systems. The missile veers off course on a failed roll. A successful roll at -3 on the next turn brings it back on target, otherwise it crashes. Vehicles with gunners using wire guidance must remain stationary or follow the weapon at less than its speed, or the missile will crash.

Infrared Homing Missiles

These are usually designed to shoot down aircraft; a typical example is the Stinger missile. They must "lock onto" their target with their own built-in sensors before firing. To lock on, roll against the sum of the guidance system's "skill" rating and the gunner's Electronics Operation (Sensor) skill, with the following modifiers:

- Add target size modifier, and subtract range modifier (not speed modifier).
- +2 if target is silhouetted against the sky.
- Subtract jam rating of infrared jammer used by target.
- Subtract any penalties for passing through hot smoke (see below).
- -5 if target just launched flares.
- +2 if target is exceptionally hot (using rocket engine, on fire, etc.).
- -7 if missile is early TL7 and not launched toward the hot rear exhaust pipe of a vehicle with a jet engine or gas turbine, or rocket engine.
- Subtract any penalties for target's infrared cloaking system.

Semi-Active Laser Homing Missiles

The missile will home on the target as long as the target is illuminated by the missile's laser designator (p. 49). The GM may require a Forward Observer skill roll to successful use a laser designator for this purpose. Roll for lock-on as for infrared homing missiles above. Modifiers are:

- Add target size modifier, and subtract range modifier (not speed modifier).
- -5 if target has is shrouded by smoke, or -10 if prismatic smoke.

Ammunition Effects

AP, API, APDS, APFSDS, APFSDSDU: These rounds all have an armor divisor; armor DR is divided by the indicated amount. In all cases, damage that penetrates flesh is halved after subtracting DR.

CHEM: Fills the indicated radius with smoke, gas, etc. depending on what was in the round. See p. 54 for smoke effects.

High Explosive (HE): Inflicts concussion and fragmentation damage using rules on p. B121. The DR of nonliving targets (like vehicles) and the DR of any character in sealed armor is squared against an ordinary HE-type explosion's concussion damage. If an explosive round goes off in direct contact with flesh (that is, if the target doesn't have any armor), damage is doubled.

SAPHE: This does normal crushing damage; DR protects at double value. In addition, it

Vehicular Combat Modifiers

Vehicles take the usual modifiers for ranged fire – see p. B201. In addition, apply the following:

Other Firing Modifiers

Target Position and Cover	
Shooting at rider on a saddle seat, on deck (unless prone)	0
Shooting at occupant of exposed seat, or using open mount weapon	-3
Shooting at occupant through window	-4
Target in a clump of light woods	-2
Target in dense forest or jungle	-4
Targeting System	
Dedicated targeting computer	+3
Radar or laser rangefinder	+2
Fire From Moving Vehicles	
Good road or in the air	-1
Bad road or in the water	-3
Off-road or in rough waters	-4
A vehicle-mounted weapon will provide a bonus to hit (usable only to reduce this penalty) depending on how the weapon is mounted:	
Firing vehicle has SR 5 or more	+1
Open mount	+1
Weapon in body, wings, or turret	+2
Stabilized weapon	+1
Fully stabilized weapon	+3
Failed control roll this turn	-1 × amount failed
Target flying, both it and firing vehicle are moving, and firing character is not the vehicle operator	-4
Weapon System	
Firing hand weapons from cramped seat/station	-2
Firing hand weapons while controlling a vehicle	-4
Vehicle operator is firing a weapon that is built into body or wing, or attached to a hardpoint, from moving vehicle	skill (limited to relevant vehicle operation skill) -3
Modifiers to SS Rating	
HUDWAC	-2, or -4 with pupil scanner (if weapon is installed in a rotating turret or open mount)

explodes for the indicating exp. damage and fragmentation damage like an HE round. If the cr. damage penetrated DR, the explosion is inside and ignores its DR (or if in flesh, damage is × 5).

High-Explosive Anti-Tank (HEAT): A near miss has much the same effect as a near miss by an HE round, but on a direct hit, the DR of any target that is *directly* struck protects at only one-tenth its normal value; HEAT has a (10) armor divisor. This is a big difference from armor DR being squared vs. concussion damage! Laminate armor is designed to disrupt the jet produced by HEAT attack and gets twice its DR against direct hits from HEAT rounds. Since this is then divided by 10, it means that laminate armor effectively gets one-fifth DR vs. HEAT. HEAT counts as flame attacks for setting fires.

HEDP and HEAT-MP: As HEAT, except HEAT-MP has only a (5) armor divisor. Two sets of damage are listed. The first applies to a target struck by a direct hit; the second is treated as HE damage, and will affect anyone in the area, as per normal explosion rules.

Annular Blast Fragmentation (ABF): This works like an HE round, but if it is fired and misses by 4 or less, use the *Scattering* rules (p. 50), even against flying targets, to see how close to the target the round passed. If the round came within 10 yards, it will explode, detonating at that distance from the target and spewing fragments in a 60° cone in front of it. Check to see if the target (or anything else) is within range of concussion and fragmentation damage.

Water: Damage is only knockback (1 hex per 8 damage); if knocked back into something solid, assess 1d damage per 2.5 hexes of knockback. Water may be dyed (to mark protesters, etc.). Water cannons can also put out fires.

Decoys and Chemical (CHEM) Rounds

These are commonly fired from decoy dischargers or large caliber guns. Instead of damage, these have a radius of effect in yards.

Smoke: Covers indicated area with dense chemical smoke; see weapon table for mortars, or p. 26 for dischargers. Smoke takes 5 seconds to fill the area and lasts for about 300 seconds divided by wind speed in mph (maximum 300 seconds). All visually aimed attacks or sighting through chemical smoke will have at least a -5 penalty. Note that other sensors, like infrared or radar, are unaffected. Smoke is ineffective underwater.

Hot Smoke: As above, but lasts half as long and penalizes infrared and thermograph sensors or aimed attacks as well as visual ones.

Chaff: Bursts into a cloud of conductive strips designed to reflect radar signals, producing a huge, diffuse target that can distract incoming missiles or give the vehicle something to hide behind. It disperses in 150 seconds divided by wind speed in mph (max 150 seconds). All attempts at detection with radar are at -10 (or -2 per yard, whichever is worse). Air-launched chaff will also drift downward at about 5 yards/turn.

Flare: A hot-burning flare, usually launched from a discharger, that is used to decoy away infrared homing missiles. An IRH missile is -5 to its attack roll if the vehicle has launched a flare of equal or higher TL than the guided weapon.

Prismatic Smoke: This is similar to smoke, but also blocks laser rangefinder beams (negating their bonus) and affects SALH missiles (p. 12).

Attacking Vehicles

Attacks on a vehicle must specify whether the body or a particular subassembly is the target. Only exposed parts of a vehicle may be targeted. For example, if a tank is behind a hill, with only its turret visible, only the turret can be hit.

Critical hits against vehicles cannot be dodged. Roll 3d: on any roll below 8 or above 12, the hit does double damage. On a 9-11, it does normal damage, but may hit a transparent canopy or window; see *Visibility and Windows,* p. 51. Alternatively, use the table on p. CII62.

Different parts of the vehicle will have different reactions to major damage. They may have different PD and DR values as well, in which case these are used instead of the body PD and DR.

Random hit location is used when a part of the vehicle must be randomly targeted. It is suggested that random hit location be used for indirect fire, for any fire beyond 1/2D range, and – at the GM's option – for automatic fire.

If a rolled location could not be hit, treat as a body hit. If a result covers multiple locations (e.g., "small turret" is rolled but the vehicle has several small turrets), roll randomly to determine which location was actually hit.

Hit Location Table

Random Location	*Hit Location*	*Hit Penalty*
3-5	Small turret	-5
6 or 8	Open mount	-2
9 or 11	Body	0
7 or 10	Large turret	-1
12-14	Wing or track	-2
15-16	Skid, wheel, or rotor	-4
17-18	Vital area	-6

The penalties are cumulative with the vehicle's Size Modifier. Thus, a large turret (-1) on a vehicle with a +3 Size Modifier is actually at +2 to hit. (The modifiers are already incorporated into the sample vehicles on pp. 60-64.)

A "small" turret is one whose volume is under one-fifth the vehicle's total volume; other turrets are "large." "Vital area" means a vital location (e.g., the power plant) is hit. Treat this as a body hit, but damage that exceeds the vehicle's DR is multiplied by 1.5.

Vehicular Dodge

PD protects vehicles the same way it does people. A vehicle may Dodge if the GM rules that it is moving in an evasive fashion. If using the maneuver rules, this means it must have made a 15° or greater bend, or have performed a stunt (such as a bootlegger) in its previous turn. A vehicle's Dodge is its operator skill/4 (Driving or Motorcycling) for most ground vehicles, or Piloting/3 for helicopters. Combat Reflexes adds its usual bonus.

Super Strength vs. Vehicles

A super, dinosaur, dragon, atomic monster, robot, or any other super-strong character, as well as a vehicle with arms, can use its physical abilities to damage a vehicle in ways beyond simply crushing or punching it. A successful grapple attack (roll the contest vs. the vehicle's Dodge rather than the operator's skill) allows a strong attacker to attempt one of the following:

Throw It: If the attacker is strong enough to lift the vehicle, he can throw it. If a vehicle is thrown, it will "collide" with whatever it hit (this may be the ground). Its speed is equal to 2 mph times the maximum distance it could have been thrown (not the actual distance). All normal effects of collision (p. 47), including whiplash, apply.

Overturn It: This requires only half the ST needed to lift the vehicle, and can be done by several people combining to push it. (This is how rioters disable cars.) A vehicle that is flipped over takes damage equal to a sideswipe collision with an immovable object (the ground) at 5 mph. Also, any overturned vehicle is unable to move. A thrown vehicle lands overturned on a roll of a 1-3 on 1d.

Tear Open a Hatch: Roll a Quick Contest between the hatch or door's (HP+DR) and the user's ST. If the HP and DR of the hatch or door are unknown, assume that HP are equal to vehicle weight in tons (maximum 50 HP) and that DR is equal to the DR of the side the hatch or door is mounted on. One attempt can be made each turn. Success allows the attacker to enter the vehicle's crew or passenger compartment.

Bend a Gun Barrel: A gun barrel normally protrudes from the body or turret. Bending it requires grabbing it, bracing oneself, and yanking hard. This normally requires at least one second per attempt. The ST roll is made at a penalty of -[10 + (weapon weight in lbs./100)]. A weapon with a bent barrel may not fire. The GM can rule that some weapons do not have barrels, or that the barrels of weapons that are concealed do not protrude.

Damaging Vehicles

A successful attack strikes the vehicle's body or a subassembly (see *Hit Location*); if this is a body or turret whose PD and DR varies by face, it is assumed to have struck on the side that is facing toward the attacker.

When a vehicle is struck, use the unmodified damage rolled to check for a hazard (p.43). Then subtract the vehicle's DR (which may vary by location and facing). Laminate DR is doubled against shaped-charge warheads. Some weapons have armor divisors, noted in parentheses. (0.5) means that the weapon is only half as good as usual at penetrating DR: it protects at double value. (2), (3), (5) or (10) means the weapon is especially good at penetrating armor DR; divide the armor's effective DR by the number given.

Apply remaining damage to the body or subassembly's hit points.

When a body or subassembly reaches 0 HPs, it becomes disabled. All components within it quit working. If the body is disabled, moving ground vehicles take an immediate -10 hazard, and aircraft go to the Disaster heading on the *Aerial Loss of Control table,* p. 44.

At -1 × HP, and every 5 HPs thereafter, the vehicle must make a HT roll or the body or subassembly in question is destroyed, which means it is disabled, can never be repaired, and that all subassemblies it supports are also disabled. Destruction is automatic at -5 × HP, and a body or subassembly is blown to bits at -10 × HP.

Motive System Damage

Damaging motive subassemblies has special effects. Hazards only apply if the vehicle is moving and using the motive system in question (e.g., a helicopter that is flying in the air does not suffer any special hazard if its wheels are shot off).

Wheels: If the target has one or two wheels, disabling any wheel drops gSpeed to 0 and inflicts a -10 hazard. If it has three wheels, disabling the front or both back wheels drops gSpeed to 0 and inflicts a -7 hazard; losing one rear wheel halves gSpeed and inflicts a -4 hazard. For four or more wheels, each lost wheel drops gSpeed by 10% and inflicts a -2 hazard; gSpeed is halved when half of all wheels are lost, and becomes 0 with a -6 hazard when all wheels on two corners are lost.

Tires: All wheels have tires. Wheel attacks from the side hit the tire instead 50% of the time, 100% of the time from other directions. Tires have as many HPs as their wheels have, but only PD 2, DR 2 (DR 3 if puncture-resistant). Disabling one is the same as disabling its wheel, but replacing a tire is an easy repair job.

Tracked: Any target with tracks drops to gSpeed 0 and takes a -2 hazard upon losing one track. Any attack doing 10% or more of a track's HPs has a 2-in-6 chance of slipping or jamming the track, even before disabling, but is an easy repair from outside the vehicle.

Wing and Rotor Damage

Stub Wings: Disabling stub wings has no special effect, other than disabling any systems attached to the wings.

Rotors: Disabling any of these immediately inflicts a Disaster result on the Aerial Loss of Control table. If rotors are disabled while the vehicle is on the ground, it can't fly safely.

Damage to Occupants

If damage from an attack or collision penetrates an occupied body or turret, roll 1d for every 100 points of penetrating damage, rounding up. Each 6 rolled means one random or GM-chosen occupant takes 50 points or half the penetrating damage, whichever is less. Exception: If the penetrating damage exceeded the occupied body or turret's original HPs, each 5-6 is a hit of 100 hits or the penetrating damage, whichever is less.

Spall Liners: If a turret or body has a spall liner, it reduces the chance and severity of casualties. Roll per 200 rather than per 100 points, and halve the damage.

Fire and Explosion

Whenever a vehicle's DR is penetrated by a flame attack (high explosive, HEAT, hot fragments from fragmentation, APFSDSDU or API ammunition, Molotov cocktails, fireball, dragon's breath, laser beam, etc.) roll 3d vs. the penetrating damage. If the result is equal to or less than the damage, the vehicle catches fire.

Also, when a body or subassembly containing fuel tanks takes more than half its HPs in damage from a single attack, roll 3d vs. the Fire number of the fuel carried (p. 21). Add +4 for a flame attack. A roll equal or less than the modified Fire number means the vehicle catches on fire.

A fire does 2d to the body or subassembly that caught fire, and another 2d every 10 seconds, ignoring DR. Heavy compartmentalization subtracts 2.

If the fire does 8 or more hits, it starts another fire. A fire that does 4 or fewer hits dies out.

Each 10 seconds that a body or subassembly with fuel tanks burns uses up 1d×5% of the tank's full fuel capacity. At the end of each 10 seconds, roll 3d vs. half the Fire number. If the roll is less than that, the fuel explodes. Gas or diesel fuel does 6d×15 per remaining gallon. If the vehicle has self-sealing fuel tanks, reduce the explosion damage to 25% of what it would normally do.

An ongoing fire can cause an ammunition explosion (see below).

Ammunition Explosions

If a body or subassembly that contains ammunition with explosive warheads, any ammunition of 20mm or larger caliber, or any rockets or missiles, is reduced to 0 hit points or on fire, check for an ammunition explosion (roll each turn if the vehicle is on fire).

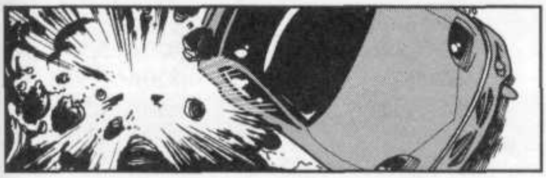
Roll 1d: An explosion occurs on a roll of 6, or on a 5-6 if the damage came from a flame weapon (see *Fire and Explosion*, above). If the ammunition is kept in an anti-blast magazine, roll 3d: on a 13 or less, the explosion does not damage the vehicle, but the ammunition is destroyed.

To determine the damage from an ammunition explosion, use the damage of 1d shots (or whatever's left) in the weapon or in any ready-to-use magazine (for nonexplosive ammunition, use WPS/2 damage, e.g., if WPS is 50, damage is 25d per shot). Damage is applied immediately vs. the body or subassembly where the ammunition was stored. Vehicle DR does not protect against this damage.

Firefighting

Fire suppression systems get a roll to put out a fire immediately, with another roll allowed every 10 seconds. Fire extinguisher systems do not roll immediately, but start after 10 seconds. Make a single, separate roll for each fire in the vehicle. Basic roll to succeed is 9 or less on 3d; -1 per separate fire going on at once, +1 per fire extinguisher or compact fire suppression system in the vehicle, +4 per full-sized fire suppression system.

Individuals with buckets or hand-held extinguishers can also attempt to put out fires, if they aren't doing anything else: each person can fight a maximum of one fire at a time. Roll 6 or less on 3d to put out a fire manually, or 9 or less if using an extinguisher. One roll is allowed every 10 seconds, but any roll of 17 or 18 means the firefighter takes 2d burn damage. Roll at +4 if fighting a methanol fire and water is available.



Weapon Tables

The weapon tables give the information needed to use vehicular weapons in a format similar to the ***GURPS Basic Set*** and ***GURPS High-Tech***.

Ammo: The type of ammunition or warhead. See *Gun and Missile Ammunition,* pp. 10-11.

Malf: The chance of a malfunction occurring. Crit. means it occurs on a critical failure. Ver. means it is very rare: on a critical failure, reroll; only a second critical failure causes a malfunction. Fixing it requires an Armory skill roll and at least one turn (divided by RoF, if RoF 1/2 or less).

Type: This is the same as in the ***Basic Set***, with one addition: exp. indicates the weapon's attack inflicts explosive damage.

Damage: The damage inflicted. For example, 6d×10 means roll six dice and multiply the result by 10 to find damage. A parenthetical number after damage is an armor divisor; DR is divided by that number against the attack. SAPHE rounds list first crushing and then explosive damage. A bracketed number after explosive damage is fragmentation damage (p. B21). A + means damage in flesh is multiplied by 1.5 after armor.

1/2D: The range beyond which damage is halved, and, unless using a fully stabilized weapon in direct fire, Acc drops to 0. Parenthetical 1/2D range means Acc is reduced normally, but damage is not (as it's an explosive warhead). For SAPHE, only cr. damage is reduced past 1/2D range.

Max: The maximum range at which it is practical to hit a target object.

RoF: The rate of fire. NR means not reloadable (in combat); this also applies to all hardpoint-mounted launchers and missiles.

Shots: This usually depends on how much ammunition is carried.

Guid: The guidance system used by a missile. WG is wire-guided, SALH is laser-guided, IRH is infrared-homing, RG is radio-guided.

Min: The minimum range of the weapon. A missile is not guided and a missile or rocket fuse will not detonate if fired at a target closer than this.

Spd: A missile's speed in yards per second; double it to get mph.

End: The seconds a missile can fly before it crashes.

Skill: A homing missile has its own skill rating; OG means it depends on the operator.

Guns

Gunner (Machine Gun)

Weapon	Ammo	Malf.	Type	Damage	SS	Acc	1/2D	Max	RoF
7.62×51mm Machine Gun (M240)	solid	ver.	cr.	7d	17	10	1,000	4,200	12
7.62×54mmR Machine Gun (PKT)	solid	crit.	cr.	7d	17	10	1,000	4,200	11
7.62×51mm Chain Gun (L94A1)	solid	ver.	cr.	7d+1	20	11	1,000	4,200	9*
7.62×51mm Minigun (M134)	solid	ver.	cr.	7d	17	10	1,000	4,200	66
12.7×99mm Machine Gun (M2HB)	solid	crit.	cr.	13d+1+	19	15	1,800	7,400	8*
12.7×108mm Machine Gun (NSV-12.7)	solid	crit.	cr.	12d+2+	19	15	1,500	7,100	12
12.7mm 3-bar. Minigun (GAU-19/A)	solid	ver.	cr.	12d+2+	19	14	1,500	7,100	33
12.7×99mm 4-bar. Minigun (YakB-12.7)	solid	ver.	cr.	12d+2+	19	14	1,500	7,100	70
14.5×114mm Machine Gun (KPV)	solid	crit.	cr.	15d+2+	20	16	2,000	8,500	10

Gunner (Grenade Launcher)

Weapon	Ammo	Malf.	Type	Damage	SS	Acc	1/2D	Max	RoF
30mm AGL (AGS-17)	HE	crit.	exp.	2d+2[2d]	20	8	(800)	1,900	6*
40mm AGL (MK19 MOD 3)	HEDP	crit.	exp.	6d(10)+2d[3d]	20	10	(1,650)	2,400	5*
40mm Electric AGL (M129)	HE	ver.	exp.	3d[3d]	20	8	(1,650)	2,400	6

Guns (Continued)

Gunner (Cannon)

Weapon	Ammo	Malf.	Type	Damage	SS	Acc	1/2D	Max	RoF
20mm Autocannon (Rh202)	API	crit.	cr.	3d×7(2)	20	15	2,000	7,500	15*
	SAPHE	crit.	cr./exp.	3d×7(0.5)+1d-4[2d]	20	15	2,000	7,500	15*
20mm 3-bar. Gatling (M197)	API	ver.	cr.	6d×3(2)	20	14	1,500	6,000	12
	SAPHE	ver.	cr./exp.	6d×3(0.5)+1d-4[2d]	20	14	1,500	6,000	12
20mm 6-bar. Gatling (M168)	API	ver.	cr.	6d×3(2)	20	14	1,500	6,000	50
	SAPHE	ver.	cr./exp.	6d×3(0.5)+1d-4[2d]	20	14	1,500	6,000	50
23mm Autocannon (AZP-23)	API	crit.	cr.	7d×3	20	14	2,000	7,000	16
	SAPHE	crit.	cr.	7d×3(0.5)+1d-2[2d]	20	14	2,000	7,000	16
23mm 2-bar. Autocannon (GSh-23)	API	crit.	cr.	6d×3(2)	20	12	1,300	5,600	56
	SAPHE	crit.	cr./exp.	6d×3[0.5]+1d-2[2d]	20	12	1,300	5,600	56
25mm Chain Gun (M242)	APFSDS	ver.	cr.	6d×8(2)	20	16	3,000	17,600	3*
	SAPHE	ver.	cr./exp.	6d×4(0.5)+1d[2d]	20	15	2,500	8,000	3*
30mm Lt. Chain Gun (M230)	HEDP	ver.	exp.	5d+2(10)+1d[2d]	20	14	1,000	4,400	10*
30mm Chain Gun (MK 44 MOD 0)	APFSDS	ver.	cr.	6d×9(2)	20	16	4,500	18,000	3*
	SAPHE	ver.	cr./exp.	6d×5(0.5)+2d-1[2d]	25	15	3,000	9,000	3*
30mm Autocannon (2A42)	AP	crit.	cr.	6d×5(2)	20	15	3,000	9,000	4*
	APDS	crit.	cr.	6d×8(2)	20	15	3,500	10,000	4*
	SAPHE	crit.	cr./exp.	6d×5(0.5)+2d-1[2d]	20	15	3,000	9,000	4*
40mm Autocannon (Bofors L70)	APFSDS	crit.	cr.	6d×12(2)	20	15	4,200	13,650	5*
	HE	crit.	exp.	4d[4d]	20	15	(2,800)	9,100	5*
76mm LP Cannon (L23A1)	HE	crit.	exp.	6d×5[6d]	20	13	(820)	5,500	1/4
	HEAT	crit.	exp.	6d×5(10)	20	13	(820)	5,500	1/4
90mm LP Cannon (CN-90-F1)	HE	crit.	exp.	6d×8[6d]	25	13	(1,650)	4,500	1/4
	HEAT	crit.	exp.	6d×6(10)	20	13	(1,650)	4,500	1/4
100mm LP Cannon (2A70)	HE	crit.	exp.	6d×10[10d]	25	12	(560)	7,700	1/5
	HEAT	crit.	exp.	6d×7(10)	25	12	(560)	7,700	1/5
76mm Rifled Gun (D-56)	APDS	crit.	cr.	6d×15(2)	30	16	2,400	9,000	1/8
	HE	crit.	exp.	6d×5[6d]	30	15	(1,600)	13,000	1/8
	HEAT	crit.	exp.	6d×5(10)	30	15	(1,600)	7,000	1/8
100mm Rifled Gun (D-10)	APDS	crit.	cr.	6d×20(2)	30	16	3,000	36,000	1/8
	APFSDS	crit.	cr.	6d×23(2)	30	16	3,000	36,000	1/8
	HE	crit.	exp.	6d×10[10d]	30	15	(3,000)	16,000	1/8
	HEAT	crit.	exp.	6d×5(10)	30	15	(3,000)	9,000	1/8
105mm Rifled Gun (L7A3)	APDS	crit.	cr.	6d×21(2)	30	16	3,300	36,000	1/8
	APFSDS	crit.	cr.	6d×24(2)	30	16	3,300	36.000	1/5
	HE	crit.	exp.	6d×11[10d]	30	15	(3,000)	16,000	1/8
	HEAT	crit.	exp.	6d×6(10)	30	15	(3,300)	9,100	1/5
120mm Smoothbore Gun (Rh120)	APFSDS	crit.	cr.	6d×30(2)	30	15	4,000	29,000	1/6
	HEAT-MP	crit.	exp.	6d×8(5)+6d×8(5)[10d]	30	14	(4,000)	9,000	1/6
120mm Lg. Smooth. Gun (CN-120-F1)	APFSDS	crit.	cr.	6d×33(2)	30	16	4,500	30,000	1/6
	HEAT-MP	crit.	exp.	6d×8(5)+6d×8(5)[10d]	30	15	(4,500)	9,500	1/6
125mm Smoothbore (2A46M)	APFSDS	crit.	cr.	6d×31(2)	30	14	4,000	29,000	1/6
	HE	crit.	exp.	6d×20[10d]	30	13	(4,000)	12,000	1/6
	HEAT	crit.	exp.	6d×8(10)	30	13	(4,000)	9,000	1/6

Gunner (Mortar)

Weapon	Ammo	Malf.	Type	Damage	SS	Acc	1/2D	Max	RoF
60mm Mortar (Soltam C04)	HE	crit.	exp.	6d×2[6d]	30	16	–	1.5 mi.	1/4
	CHEM	crit.	exp.	(13-yd.)	30	16	–	9,000	1/4
81mm Mortar (L16A2)	HE	crit.	exp.	6d×5[6d]	20	10	–	3 mi.	1/5
	CHEM	crit.	exp.	(25-yd.)	20	10	–	3 mi.	1/5
120mm Mortar (Soltam K6)	HE	crit.	exp.	6d×16[6d]	30	11	–	4.5 mi.	1/6
	CHEM	crit.	exp.	(54-yd.)	30	11	–	4.5 mi.	1/6

Gunner (Water Cannon)

Weapon	Ammo	Malf.	Type	Damage	SS	Acc	1/2D	Max	RoF
Water Cannon	water	crit.	cr.	4d	5	7	35	49	8

Notes

AP ammo uses the statistics for solid, but with (2) armor divisor. APFSDSDU uses the statistics for APFSDS, with a (3) armor divisor.

Guided Missiles

Anti-Aircraft Missiles

Type and Designation											
Warhead	***Guid.***	***Type***	***Damage***	***Spd.***	***End.***	***Min.***	***Max***	***SS***	***Acc***	***Skill***	***RoF***
70mm IRH-AAM (FIM-92D Stinger)											
SAPHE	IRH	cr.+exp.	6d×14(0.5)+6d×11[6d]	950	11	220	8,500	–	–	14	1/20 or NR
90mm IRH-AAM (Mistral)											
ABF	IRH	exp.	6d×8 [12d]	850	6	100	5,000	–	–	15	1/20 or NR
120mm IRH-AAM (SA-13 Gopher)											
ABF	IRH	exp.	6d×10 [12d]	550	9	500	5,000	–	–	14	1/20 or NR
127mm IRH-AAM (AIM-9 Sidewinder)											
ABF	IRH	exp.	6d×64[20d]	800	22	100	17,600	–	–	14	NR
170mm IRH AAM (AA-11 Archer)											
ABF	IRH	exp.	6d×32[20d]	900	22	500	20,000	–	–	15	NR

Anti-Tank Missiles

Type and Designation											
Warhead	***Guid.***	***Type***	***Damage***	***Spd.***	***End.***	***Min.***	***Max***	***SS***	***Acc***	***Skill***	***RoF***
120mm AT-4 Spigot-B											
HEAT	WG	exp.	6d×6(10)	200	13.5	80	2,700	–	–	OG	1/20 or NR
125mm MCLOS ATGM (AT-3a Sagger)											
HEAT	WG	exp.	6d×5(10)	120	25	300	3,000	–	–	OG*	1/20 or NR
125mm SACLOS ATGM (MILAN-2)											
HEAT	WG	exp.	6d×12(10)	180	12.5	25	2,200	–	–	OG	1/20 or NR
130mm RCG SACLOS ATGM (AT-6a Spiral)											
HEAT	RCG	exp.	6d×9(10)	400	14	400	5,500	–	–	OG	1/20 or NR
130mm RG ATGM (AT-9 Ataka)											
HEAT	RCG	exp.	6d×13(10)	440	14.5	400	6,500	–	–	OG	1/20 or NR
135mm SACLOS ATGM (AT-5 Spandrel)											
HEAT	WG	exp.	6d×8(10)	230	19	80	4,400	–	–	OG	1/20 or NR
152mm SACLOS ATGM (TOW-2A)											
HEAT	WG	exp.	6d×12(10)	360	20	75	4,100	–	–	OG	1/20 or NR
165mm SACLOS ATGM (HOT-3)											
HEAT	WG	exp.	6d×17(10)	260	17	80	4,400	–	–	OG	1/20 or NR
178mm SALH ATGM (AGM-114C Hellfire)											
HEAT	SALH	exp.	6d×18(10)	475	19	500	8,800	–	–	18	1/20 or NR

Gun/Launcher

Type and Designation											
Warhead	***Guid.***	***Type***	***Damage***	***Spd.***	***End.***	***Min.***	***Max***	***SS***	***Acc***	***Skill***	***RoF***
100mm SALH ATGM (AT-10 Stabber)											
HEAT	SALH	exp.	6d×7(10)	320	15	100	5,500	–	–	12	1/20
125mm SALH ATGM (AT-11 Sniper)											
HEAT	SALH	exp.	6d×9(10)	460	17	100	5,500	–	–	12	1/20

* SAPHE explosive damage: 6d×2[6d].

Notes: Different versions of missile may have different statistics. For example: Earlier MILAN-1 is 6d×8(10); Improved TOW is 6d×9(10); HOT-1 is 6d×9(10); newer AT-3c is 6d×7(10) and SACLOS guidance.

Rocket Launchers

Unguided Rocket Pods (Gunner/TL (Rocket Launchers)

Weapon	***Ammo***	***Malf***	***Type***	***Damage***	***SS***	***Acc***	***Min***	***1/2D***	***Max***	***RoF***	***Shots***
70mm 7-shot Rocket Pod (M260)	HE	crit.	exp.	6d×6 [6d]	20	6	250	(3,750)	8,000	7*	7
70mm 19-shot Rocket Pod (M261)	HE	crit.	exp.	6d×6 [6d]	20	6	250	(3,750)	8,000	19*	19
80mm 7-shot Rocket Pod (B-8V-7)	HEDP	crit.	exp.	6d×5(10)+6d×4[6d]	20	6	400	(4,200)	9,000	7*	7
80mm 20-shot Rocket (B-8V-20)	HEDP	crit.	exp.	6d×5(10)+6d×4[6d]	20	6	400	(4,200)	9,000	10*	20

Sample Vehicles

5

This chapter presents eight vehicle designs in the standard format used to describe vehicles in other ***GURPS*** books. Use these as a guide when creating your own vehicle designs.

Vehicle Key

The following descriptions list components in an easy-to-use format:

Abbreviations: Those in use include Tur for turrets, Whl for wheels, OM for open mount, and Wng for wings.

Body and Subassemblies: The number following the body and each subassembly gives the bonus or penalty when attacking that particular part of the vehicle.

Powertrain: Describes the size and type of all propulsion and lift systems, power plants, and energy banks.

Fuel: For fuel, gives the amount and type (with Fire number in parentheses).

Occupancy: Each number is followed by an abbreviation. CCS is a cramped crew station, NCS a normal crew station, and RCS a roomy crew station. Passenger seats use CS, NS, and RS for cramped, normal, and roomy positions, respectively. An exposed position is noted with an X (for instance, XNCS for an exterior normal crew station). Cycle crew stations are listed as "cycle."

Cargo: Gives capacity in cubic feet. Each cubic foot generally holds 20 lbs.; exceptions are noted.

Armor: Vehicles without this notation have no armor. F indicates frontal armor, RL right and left, B back, T top, and U underside. If the entire body or subassembly has the same armor, only one value is listed. Any letters following PD/DR values indicate laminate (L) or composite (C) armor. Special circumstances are detailed just below the tabular columns of armor values.

Weaponry: Vehicles without this notation have no integral weapons. For those that do, the location notation also gives the facing of the weapon, per *Armor.* Ammunition listings include all shots stored on the vehicle. Following each weapon is the bonus provided by the vehicle's targeting systems. For other weapon statistics, see the *Weapons Tables* (pp. 57-59).

Equipment: Grouped by location, these are the accessories that have significant effects in the game; others are described in the *Design Notes.*

Statistics: *Dim.* is a *rough* indication of dimensions, usually length × width × height. *Payload* is the sum of the usual payload (occupants and cargo), fuel, and ammunition weights. *Price* is the full price excluding fuel and ammunition. *Lwt.* is loaded weight; the lowercase letter before a performance rating indicates a mode of travel; *g* is ground, *a* is air, *w* is water, e.g., *gSpeed* is top ground speed, and *aMR* is the aerial maneuver rating.

Design Notes: A compilation of data that rarely come up in play, but are useful for reverse-engineering or modifying the design.

Suzuki GSX1300R Hayabusa

The Hayabusa ("peregrine falcon") is the world's fastest production motorcycle, with a top speed approaching 200 mph. Introduced in 1999, it is an aluminum-bodied machine with a sleek aerodynamic look, and a performance hitherto only found in purpose-built racers. It uses 5.08 gallons of gasoline per hour. A full load of fuel costs $8.70. Visibility is good.

Subassemblies: Body +1, 2 Wheels -3.
Powertrain: 127-kW improved wheeled drivetrain, 127 kW improved HP gasoline engine, 430 kWs lead acid battery.
Fuel: 5.8 gallons gasoline (fire 11).
Occupancy: 1 XCS (cycle)

Statistics

Size: 7'×2.5'×4'	*Payload:* 235 lbs.	*Lwt.:* 0.35 tons
Volume: 16 cf	*Maint.:* 168 hrs.	*Price:* $14,050

HT: 12. HPs: 30 Body, 6 each Wheel.

gSpeed: 200 *gAccel:* 15 *gDecel:* 10 *gMR:* 1.75 *gSR:* 3
Ground Pressure High. 1/6 Off-Road Speed.

Design Notes

Body is 15 cf; wheels are 1.5 cf. Structure is light, expensive. It has improved suspension. Mechanical controls. Empty weight is 475 lbs. 0.387 cf empty space in body. Design uses extra detail option for top speed.

Ford Mustang

The 2002 Mustang GT Standard is a typical 2-door sports coupe. The Mustang seats four people (two in front, two in back). It burns 5.76 gallons of gasoline per hour. A full load of fuel is $23.55. Visibility is good.

Subassemblies: Body +3, 4 Wheels -1.
Powertrain: 144-kW wheeled drivetrain, 144 kW std. gasoline engine, 2,000 kWs lead acid battery.
Fuel: 15.7 gallons gasoline (fire 11).
Occupancy: 1 NCS, 1 NS, 2 CS ***Cargo:*** 10.9 cf

Armor	F	RL	B	T	U
All:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: Sound system; burglar alarm; airbags (NCS and NS); 4-man environmental control.

Statistics

Size: 15'×6'×4.5' *Payload:* 0.56 tons *Lwt.:* 2 tons
Volume: 187 cf *Maint.:* 154 hrs. *Price:* $16,815

HT: 12. HPs: 150 Body, 15 each Wheel.

gSpeed: 145 *gAccel:* 5 *gDecel*: 15 *gMR:* 0.75 *gSR:* 4 Ground Pressure High. 1/6 Off-Road Speed.

Design Notes

Body is 170 cf with fair streamlining; wheels are 17 cf. Structure is light, cheap. It has improved brakes. Armor is cheap metal. Mechanical controls. Empty weight is 2,945 lbs. Design uses extra detail option for top speed.

Toyota Land Cruiser

The 2002 Land Cruiser is a rugged luxury sport utility vehicle with a powerful V-8 engine and robust four-wheel drive. The SUV seats five people (two in front, three in back), but can replace the large cargo area with three more seats. It burns 6.88 gallons of gasoline per hour. A full load of fuel is $38.10. Visibility is good.

Subassemblies: Body +4, four Wheels +0.
Powertrain: 172-kW all-wheel-drive, 172 kW std. gasoline engine, 3,000 kWs lead-acid battery.
Fuel: 25.4 gallons gasoline (fire 11).
Occupancy: 1 RCS, 1 RS, 3 NS ***Cargo:*** 97.5 cf

Armor	F	RL	B	T	U
All:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: Receive-only radio; GPS; burglar alarm; airbags (RCS and RS); luxury interior (RCS and RS); 5-man environmental control. *External:* Hitch.

Statistics

Size: 16'×6'×6' *Payload:* 1.6 tons *Lwt.:* 4 tons
Volume: 359 cf *Maint.:* 93 hrs. *Price:* $45,720

HT: 12. HPs: 450 Body, 45 each Wheel.

gSpeed: 105 *gAccel:* 5 *gDecel*: 15 *gMR:* 0.5 *gSR:* 4 Ground Pressure High. 1/4 Off-Road Speed.

Design Notes

Body is 326 cf; wheels are 32.6 cf. Structure is medium, standard. It has improved brakes. Armor is cheap metal. Mechanical controls. Empty weight is 5,041 lbs.

Variant: Armored Toyota Land Cruisers are popular vehicles for executives, special ops, politicians, and war correspondents in war-torn regions. Several companies offer armor upgrades: add DR +14 expensive composite armor and puncture-resistant tires. Adds 1,312 lbs. and $20,685. Loaded weight 4.728 tons. gSpeed is 95 mph if fully loaded.

McDonnell Douglas MD 500D

This is a popular turbine-powered light helicopter based on the earlier OH-6A Cayuse (used by the U.S. Army in Vietnam) and Hughes 500. It has an egg-shaped fuselage with glazed nose, and is of conventional top-and-tail rotor configuration, with an H-shaped tail.

The civilian model is used for a wide variety of missions, from border patrol to aerial photography. The military export model, the MD 500M Defender, comes in variants optimized for scout, special operations, naval, and anti-tank missions. 28 nations use it, including Brazil, Israel, Japan, and both Koreas. The civilian MD 500D is also easy to upgrade to military specifications . . . as North Korea has done.

The MD 500 seats a pilot, copilot, and three passengers, with the passenger compartment accessed by side doors. Two hardpoints are commonly installed on the right and left fuselage, for mounting cameras or (in the military versions) weaponry. Back seats can be removed to add cargo space, if desired. It burns 21.91 gallons of jet fuel per hour at cruising speed. A full load of fuel is $819. Visibility is good.

Subassemblies: Body +3, Top-and-Tail Rotor -1, two Skids -1.
Powertrain: 313-kW TTR drivetrain, 313-kW HP gas turbine; 1,470 kWs advanced battery.
Fuel: 63 gallons jet fuel (fire 13).
Occupancy: 2 CCS, 3 CS

Armor	F	RL	B	T	U
All:	2/3	2/3	2/3	2/3	2/3

Equipment

Body: Long-range radio; autopilot; GPS; navigation instruments; transponder; compact fire suppression; 5-man environmental control. *External (on body):* Two 245-lb. hardpoints.

Statistics

Size: 31'×6'×9' *Payload:* 0.7 tons *Lwt.:* 1.53 tons
Volume: 161 cf *Maint.:* 48 hrs. *Price:* $171,685

HT: 12. HP: 131 Body, 59 Rotors, 9 each Skid.

aSpeed: 180 *aAccel:* 3 *aDecel*: 16 *aMR:* 4 *aSR:* 3 Stall speed 0.

Design Notes

Body is 150 cf; rotor is 3 cf; skids are 7.5 cf. Structure is light, expensive, with fair streamlining. Armor is expensive metal. Mechanical controls. Fuel tank is light, self-sealing. Empty weight is 1,652 lbs. Performance is without loaded hardpoints; with hardpoints, speed drops to 170 mph. Each fully loaded hardpoint subtracts from payload, meaning one fewer passenger can be carried per hardpoint that is fully loaded. However, less fuel can also be carried, trading range for load capacity. 3.97 cf empty space in body.

A civilian MD 500D is about $395,000.

Variants: There are many different versions and optional equipment packages (different batteries, auxiliary fuel tanks, etc.). For example, the MD 500MD *TOW Defender* attack helicopter adds an advanced radar detector, a scrambler, 2-mi. thermograph, and four loaded TOW missile launchers, two per hardpoint.

FLD 120 Freightliner

The FLD 120 is one of the most popular "big rigs" on the highways of North America and the world, usually hitched to a 48' semi-trailer. Freightliners are available in several models; this one has a "sleeper" cab with a bunk bed and storage space, a roof-mounted faring, and a big 470-hp engine. It burns 12.25 gallons of diesel fuel per hour. A full load of fuel is $360. Visibility is fair.

Subassemblies: Body +4, six heavy Wheels +0.
Powertrain: 350-kW wheeled drivetrain, 350 kW std. turbocharged diesel engine, 8,000 kWs batteries.
Fuel: 300 gallons diesel (fire 9).
Occupancy: 1 RCS, 1 RS, 1 bunk ***Cargo:*** 20 cf

Armor	F	RL	B	T	U
All:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: Short-range radio; 2-man environmental control. *External:* Hitch.

Statistics

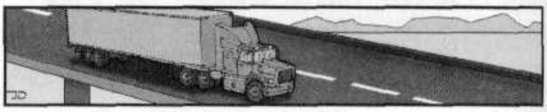
Size: 24'×8'×10' *Payload:* 1.3 tons *Lwt.:* 10.3 tons
Volume: 426 cf *Maint.:* 79 hrs. *Price:* $63,995

HT: 12. HPs: 2,400 Body, 250 each Wheel.

gSpeed: 110 *gAccel:* 5 *gDecel*: 15 *gMR:* 0.75 *gSR:* 5 Ground Pressure Very High. 1/8 Off-Road Speed.

Design Notes

Body 355 cf; wheels 71 cf. Structure is extra-heavy, very cheap; improved suspension and brakes and a rooftop fairing. Armor is cheap metal. Mechanical controls. Empty weight is 17,891 lbs.



Van Semi-Trailer

Various types of semi-trailers are hitched to semi-tractor trucks. This is an enclosed 48' trailer. Statistics are for a usual load of 24 tons, but it's quite possible to exceed this.

Performance statistics assume it's hitched to the Freightliner semi-truck above.

Subassemblies: Body +5, eight Wheels +1.
Occupancy: None. ***Cargo:*** 2,400 cf

Armor	F	RL	B	T	U
All:	3/3	3/3	3/3	3/3	3/3

Equipment

Body: Rear cargo ramp. *External:* Pin.

Statistics

Size: 48'×8'×10' *Payload:* 24 tons *Lwt.:* 32 tons
Volume: 2,640 cf *Maint.:* – *Price:* $43,950

HT: 12. HPs: 1,800 Body, 94 each Wheel.

gSpeed: 55 *gAccel:* 2 *gDecel*: 15 *gMR:* 0.25 *gSR:* 6 Ground Pressure Very High. 1/8 Off-Road Speed.

Design Notes

Body is 2,400 cf; wheels are 240 cf. Structure is medium, cheap. It has improved brakes. Armor is cheap metal. Performance assumes it is hitched to Freightliner (above).

Variants: A "Lowboy" open trailer can have up to twice the maximum load, but is not enclosed (no armor protection for load). Lwt. 30.62 tons (with 24-ton load), price $41,340.

LAV-25

This is an eight-wheeled amphibious light armored vehicle, with a 25mm turreted chain gun. The LAV-25 is built by General Motors Canada and used by the U.S. Marine Corps as an armored reconnaissance and infantry fighting vehicle; this model represents one of the current upgrades. The commander and gunner occupy the turret, while the driver is seated in the front left of the hull. The troop compartment in the rear body carries six soldiers, with access through double rear doors. Two roof hatches are atop the rear hull. Extra ammunition is also stowed in the hull.

It uses 7.175 gallons of diesel fuel per hour. A full load of fuel and ammo is $3,042.80. Visibility is poor.

Subassemblies: Body +4, full-rotation Turret +3, eight off-road Wheels +0, limited-rotation Open Mount -1.

Powertrain: 205-kW all-wheel-drive with 25 kW water drive; 205-kW std. turbocharged diesel engine; 17,280-kWs lead-acid batteries.

Fuel: 79 gallons diesel (fire 9).

Occ: 2 NCS Tur; 1 NCS, 6 CS Body ***Cargo:*** 30 cf

Armor	F	RL	B	T	U
Body:	6/56	5/42	4/35	4/28	4/28
Turret:	5/42	5/42	4/28	4/28	–
Wheels:	4/27	4/27	4/27	4/27	4/27

Weaponry

25mm Chain Gun [Tur:F] (630 rounds) +0.
7.62×51mm MG [Tur:F] (1,400 rounds) +0.
7.62×51mm MG [OM:F] (200 rounds) +0.

Equipment

Body: Light amp.; navigation instruments; full fire suppression; winch (16,000-lb. tow); 7-man environmental control; 7-man NBC kit. *Turret:* Full stabilization for 25mm chain gun and 7.62mm machine gun; two short-range radios with scrambler; light amp.; two 7× telescopes; military GPS; 5-mi. thermograph; two smoke/decoy dischargers; 2-man environmental control; 2-man NBC kit. *Wheels:* Puncture-resistant tires.

Statistics

Size: 21'×8'×9' *Payload:* 1.8 tons *Lwt.:* 13.8 tons
Volume: 762 cf *Maint.:* 38 hrs. *Price:* $271,355

HT: 12. HPs: 1,200 Body, 450 Tur, 131 each Wheel.

*gSpeed:*60 *gAccel:* 3 *gDecel*: 10 *gMR:* 0.25 *gSR:* 5
*wSpeed:*4

Ground Pressure High. 1/4Off-Road Speed.

Design Notes

Body is 500 cf with 60° F and 30° R/L slope. Turret is 110 cf with 30° F/R/L slope. Wheels are 150 cf (increased volume). Open mount is 2.2 cf. Structure is heavy and cheap, with heavy compartmentalization. Armor is standard metal. Sealed structure. Mechanical controls. There are 13.4 cf of empty space in the body, 6.56 in the turret and 1.54 in the open mount for further upgrades. Empty weight is 23,955 lbs. 420 rounds of 25mm and 1,000 rounds of 7.62mm ammo are stored in the body.

The dollar price the U.S. Marine Corps paid for LAV-25s was about $900,000 each.

LAV-25 is one example of a broad family of other vehicles, all originally derived from the Swiss MOWAG Piranha. Users include the U.S., Canadian and Australian armies. Most variants keep the same body type, but modify or remove the turret.

NORINCO Type 69-II

The Type 69 tracked main battle tank is a Chinese upgrade of the old Russian T-54/T-55 design, with newer automotive and fire control systems; the 69-II is the most common version.

The tank first appeared in People's Liberation Army service in 1982, and has since been adopted by Bangladesh, Iran, Iraq, Myanmar, Pakistan, Sri Lanka, and Thailand. Iraqi Type 69s in the Gulf War proved no match for newer western tanks. The Type 69 is representative of AFVs likely to be met in developing countries or "private armies."

It has 4-man crew: the driver sits in the body, while the gunner, loader and commander are in the turret. There are hatches on the front body and the turret roof. The interior is notoriously cramped.

It uses 15.12 gallons of diesel fuel per hour. A full load of fuel and ammo is $20,756.40. Visibility is poor.

Subassemblies: Body +4, full-rotation Turret +3, Tracks +2, limited-rotation Open Mount -1.

Powertrain: 432-kW tracked drivetrain; 432-kW standard turbocharged multi-fuel diesel; 12,095-kWs lead-acid batteries.

Fuel: 247 gallons diesel (fire 9).

Occupancy: 3 CCS (turret), 1 CCS (body)

Armor	F	RL	B	T	U
Body:	6/540	4/130	4/120	4/90	4/55
Turret:	4/560	4/350	4/170	5/150	–
Tracks:	4/30	4/30	4/30	4/30	4/30

Weaponry

100mm rifled gun [Tur:F] (44 rounds) +3.
7.62×54mmR MG [Tur:F] (1,500 rounds) +0.

7.62×54mmR MG [Bod:F] (1,500 rounds) +0.
12.7×108mm MG [OM:F] (500 rounds) +0.

Equipment

Body: Compact fire suppression; smoke-screen; 4-man environmental control; 4-man NBC kit. *Turret:* Full stabilization for 100mm gun and 7.62mm machine gun; medium-range radio; 7× telescope (gunner); 5× telescope (commander); 0.5-mi. IR searchlight; laser rangefinder; dedicated targeting computer w/software for 100mm gun. *Open Mount:* Universal mount for 12.7mm machine gun; 0.25-mi. IR searchlight.

Statistics

Size: 20'×11'×9' *Payload:* 4,612 lbs. *Lwt.:* 41.68 tons
Volume: 768 cf *Maint.:* 29 hours. *Price:* $460,815.

HT: 11. *HP:* 1,200 *Tur:* 750 *Tracks:* 375 each.

*gSpeed:*40 *gAccel:* 3 *gDecel*: 20
gMR: 0.25 *gSR:* 6

Ground Pressure Low. 2/3 Off-Road Speed.

Design Notes

Body is 365 cf with 60° F slope. Turret is 182 cf with rounded design (treated as 30° top slope). Tracks are 219 cf. Open mount is 1.9 cf. Structure is heavy and cheap. Armor is standard metal. Sealed structure. Mechanical controls. There are 2.88 cf of empty space in the body and 1.37 cf in the turret for further upgrades. Empty weight is 78,743 lbs. Typical ammo mix for 100mm gun is 25 APFSDS (5 in turret), 8 HE (3 in turret), and 11 HEAT (6 in turret). 12.7mm MG ammo is in turret.

Most Type 69-IIs are made in countries with cheap labor costs, so the listed price is reasonably accurate for a new-built or slightly used example.

Variants: The older Type 69-I had a 100mm smoothbore gun; treat as 100mm rifled, but -2 to Acc. The newer Type 69-III replaces the 100mm gun with a 105mm rifled gun and substitutes 2-mi thermographs for the IR searchlights. Type-69 statistics can be used for Russian T-55 upgrades: delete the body machine gun.

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HOT WHEELS AND HEAVY METAL!

GURPS Vehicles Lite is a streamlined version of *GURPS Vehicles*, packed with new design tips and shortcuts to make vehicle design faster and easier than before! Create cars, cycles, trucks, helicopters, and armored fighting vehicles – everything from racing bikes to battle tanks.

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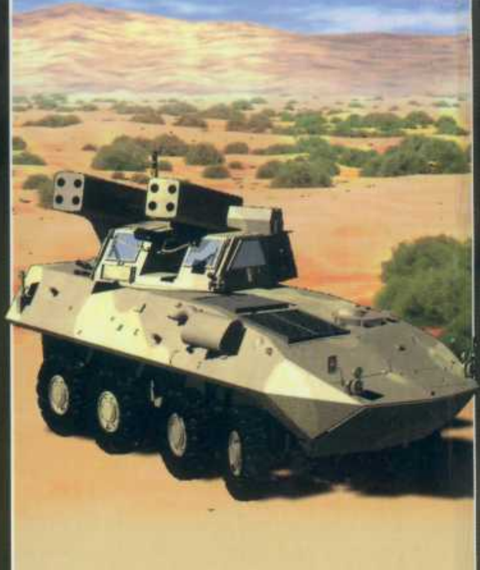

GURPS Basic Set**, Third Edition, is required* to use this supplement in a ***GURPS campaign. ***GURPS Vehicles Lite*** can be used with *any* roleplaying system.

THE ENGINEERS:

WRITTEN BY
DAVID PULVER

EDITED BY
GRAEME DAVIS AND
KENNETH PETERS

COVER BY
JESSE DEGRAFF

ILLUSTRATED BY
DAN SMITH

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