Gps Navigation Essay, Research Paper

GPS: The Future of Navigation and Technology

As we enter the 21st century, we are constantly being bombarded with new technologies. From the wireless community to operations that once took weeks to recover and now only take a day or so, our world will never be the same. Another technology that is revolutionizing the world we live in is the Global Positioning System or GPS. The first GPS satellite was called GPS Block I. Launched in 1978, it was a developmental satellite. Another nine Block I satellites were launched through 1988. GPS is the only system today able to show you your exact position on the Earth anytime, in any weather, anywhere. There are 24 GPS satellites in orbiting the world at 11,000 nautical miles above the Earth. Ground stations located worldwide continuously monitor them. They transmit signals that can be detected by anyone with a GPS receiver. Using the receiver, you can determine your location with great precision. GPS is one of history’s most exciting and revolutionary developments and new uses for it are constantly being discovered. But before I go any farther it’s important to understand a bit more about navigation. Since prehistoric times, people have been trying to figure out a reliable way to tell where they are, to help guide them to where they are going, and to get them back home again. Cavemen probably used stones and twigs to mark a trail when they set out hunting for food. The earliest mariners followed the coast closely to keep from getting lost. When navigators first sailed into

the open ocean, they discovered they could chart their course by following the stars. The ancient Phoenicians used the North Star to journey from Egypt and Crete. According to Homer, the goddess Athena told Odysseus to “keep the Great Bear on his left” during his travels from Calypso’s Island. Unfortunately for Odysseus and all the other mariners, the stars are only visible at night – and only on clear nights. The next major developments in the quest for the perfect method of navigation were the magnetic compass and the sextant. The needle of a compass always points north, so it is always possible to know in what direction you are going. The sextant uses adjustable mirrors to measure the exact angle of the stars, moon, and sun above the horizon. However, in the early days of its use, it was only possible to determine latitude, the location on the Earth measured north and south, from the sextant observations. Sailors were still unable to determine their longitude, the location on the Earth measured east or west. This was such a serious problem that in the 17th century, the British formed a special Board of Longitude consisting of well-known scientists. This group offered ?20,000, equal to about a million of todays dollars, to anybody who could find a way to determine a ship’s longitude within 30 nautical miles. The generous offer paid off. In 1761, a cabinetmaker named John Harrison developed a shipboard timepiece called a chronometer, which lost or gained only about one second a day – incredibly accurate for the time. For the next two centuries, sextants and chronometers were used in combination to provide latitude and longitude information. In the early 20th century several radio-based navigation systems were developed, which were used widely during World War II. Both allied and enemy ships and airplanes used ground-based radio-navigation systems as the technology advanced. A few ground-based radio-navigation systems are still in use today. One drawback of using radio waves generated on the ground is that you must choose between a system that is very accurate but doesn’t cover a wide area, or one that covers a wide area but is not very accurate. High-frequency radio waves (like UHF TV) can provide accurate position location but can only be picked up in a small, localized area. Lower frequency radio waves (like AM radio) can cover a larger area, but are not a good yardstick to tell you exactly where you are. Scientists, therefore, decided that the only way to provide coverage for the entire world was to place high-frequency radio transmitters in space. A transmitter high above the Earth sending a high-frequency radio wave with a special coded signal can cover a large area and still overcome much of the “noise” encountered on the way to the ground. This is one of the main principles behind the Global Positioning System. GPS has 3 parts: the space segment, the user segment, and the control segment. The space segment consists of 24 satellites, each in its own orbit 11,000 nautical miles above the Earth. The user segment consists of receivers, which you can hold in your hand or mount in your car. The control segment consists of ground stations. There are five of them, located around the world that make sure the satellites are working properly. One trip around the Earth in space equals one orbit. The GPS satellites each take 12 hours to orbit the Earth. Each satellite is equipped with an accurate clock to let it broadcast signals coupled with a precise time message. The ground unit receives the satellite signal, which travels at the speed of light. Even at this speed, the signal takes a measurable amount of time to reach the receiver. The difference between the time the signal is sent and the time it is received, multiplied by the speed of light, enables the receiver to calculate the distance to the satellite. To measure precise latitude, longitude, and altitude, the receiver measures the time it took for the signals from four separate satellites to get to the receiver.

The GPS system can tell you your location anywhere on or above the Earth to within about 300 feet. Even greater accuracy, usually less than three feet, can be obtained with corrections calculated by a GPS receiver at a known fixed location. To help you understand the GPS system, let’s take the three parts of the system – the satellites, the receivers, and the ground control – and discuss them in more detail. Then we will look more closely at how GPS works. As I said before, the complete GPS space system includes 24 satellites, 11,000 nautical miles above the Earth, which take 12 hours each to go around the Earth once (one orbit). They are positioned so that we can receive signals from six of them nearly 100 percent of the time at any point on Earth. You need that many signals to get the best position information. Satellites are equipped with very precise clocks that keep accurate time to within three nanoseconds – that’s 0.000000003, or three billionths, of a second. This precision timing is important because the receiver must determine exactly how long it takes for signals to travel from each GPS satellite. The receiver uses this information to calculate its position. The first GPS satellite was launched in 1978. The first 10 satellites were developmental satellites, called Block I. From 1989 to 1993, 23 production satellites, called Block II, were launched. The launch of the 24th satellite in 1994 completed the system. The GPS control, or ground, segment consists of unmanned monitor stations located around the world. They are in Hawaii and Kwajalein in the Pacific Ocean; Diego Garcia in the Indian Ocean; Ascension Island in the Atlantic Ocean; and Colorado Springs, Colorado. A master ground station at Falcon Air Force Base in Colorado Springs, Colorado, and four large ground antenna stations that broadcast signals to the satellites. The stations also track and monitor the GPS satellites.

GPS receivers can be hand carried or installed on aircraft, ships, tanks, submarines, cars, and trucks. These receivers detect, decode, and process GPS satellite signals. More than 100 different receiver models are already in use. The typical hand-held receiver is about the size of a cellular telephone, and the newer models are even smaller. The hand-held units distributed to U.S. armed forces personnel during the Persian Gulf war weighed only 28 ounces. So you can more easily understand some of the scientific principles that make GPS work, let’s discuss the basic features of the system. The principle behind GPS is the measurement of distance between the receiver and the satellites. The satellites also tell us exactly where they are in their orbits above the Earth. It works something like this: If we know our exact distance from a satellite in space, we know we are somewhere on the surface of an imaginary sphere with radius equal to the distance to the satellite radius. If we know our exact distance from two satellites, we know that we are located somewhere on the line where the two spheres intersect. And, if we take a third measurement, there are only two possible points where we could be located. One of these is usually impossible, and the GPS receivers have mathematical methods of eliminating the impossible location. We know that the GPS system consists of satellites whose paths are monitored by ground stations. Each satellite generates radio signals that allow a receiver to estimate the satellite location and distance between the satellite and the receiver. The receiver uses the measurements to calculate where on or above the Earth the user is located. Now that you have an idea about how the GPS functions, let’s see how we can put it to work for us. As you might imagine, GPS has many uses in both military and civilian life.

Although the GPS satellite constellation was completed only recently, it has already proved to be a most valuable aid to U.S. military forces. The mustering of forces for Desert Shield sent a wake-up call to U.S. military forces. With an average of only 39 days of training each year, National Guard and reserve troops had to work double time to prepare for Desert Storm’s offensive thrust. To ensure that an adequate number of reservists would be ready if the need should again arise, Congress established the $92 million Simulation in Training for Advanced Readiness program. From this sprang a revolutionary GPS-based battle simulation system. Major Jeff Grant explains that the battle simulation uses 70-ton Abrams tanks, Bradley fighting vehicles, and ground troops. All of the vehicles and personnel are equipped with the Deployable Force-on-Force Instrumented Range System (DFIRST). Maj. Jeff Grant pointed out that simulation takes place outside Boise Idaho. By combining off-the-shelf radio communications equipment and GPS receivers with specially developed software, DFIRST enables armored units to conduct highly realistic combat practice to improve their battle readiness. Inside the 70-ton Abrams tank, these block letters glow softly on the in-vehicle display screen, informing the crew of Charley 12 that it is now operating in a live distributed battlefield simulation. Departing from traditional training methods in which combat units travel to remote locations for two or three weeks of maneuvers, Charley 12 and its four-man crew are testing an instrumentation system that enables company-sized units to conduct force-on- force combat-readiness training on ranges near their home base. From 12,000 miles above the arid terrain, GPS satellite signals cast a net encompassing every inch of the mock battlefield. Using on-board instrumentation, Charley 12, a Blue Force team member, tracks its own movement as it traverses the ridge lines in search of defending Red Force troops. When the enemy is sighted, Charley 12’s onboard GPS receivers trace the sudden swing of the tank’s turret as the gunner locks onto the target with a 120-millimeter smoothbore gun. Grant also points out that after the gunner squeezes the trigger, within milliseconds, processing software in Charley 12’s instrumentation package verifies — based on GPS coordinates the gun pointing angle, and the tank’s known performance capabilities — that the enemy tank is within the cross hairs and effective firing range of its main gun. An electronic “hit” signal notifies the instrumentation package on the target tank that a fatal blow is imminent. The defending tank’s instrumentation package performs a simulated damage assessment, which tells the Red Force tank that it is destroyed. The victim vehicle stops in its tracks. Charley 12’s simulated round has just given the Blue Force its first victory in the brigade’s June 1996 annual training exercises. Without a reliable navigation system, U.S. forces could not have performed the maneuvers of Operation Desert Storm. With GPS, the soldiers were able to go places and maneuver in sandstorms or at night when even the troops who lived there couldn’t. Initially, more than 1,000 portable commercial receivers were purchased for their use. The demand was so great that, before the end of the conflict, more than 9,000 commercial receivers were in use in the Gulf region. They were carried by foot soldiers and attached to vehicles, helicopters, and aircraft instrument panels. GPS receivers were used in several aircraft, including F-16 fighters, KC-135 aerial refuelers, and B-2 bombers. Navy ships used them for rendezvous, minesweeping, and aircraft operations. GPS has become important for nearly all military operations and weapons systems. In addition, it is used on satellites to obtain highly accurate orbit data and to control spacecraft orientation. GPS is based on a system of coordinates called the Worldwide Geodetic System 1984, also called WGS-84, similar to the latitude and longitude lines you see on wall maps in school. The WGS-84 system provides a built-in frame of reference for all military activities, so units can synchronize their maneuvers. The GPS system was developed to meet military needs of the Department of Defense, but new ways to use its capabilities are continually being found. As you have read, the system has been used in aircraft and ships, but there are many other ways to benefit from GPS. During construction of the tunnel under the English Channel, British and French crews started digging from opposite ends: one from Dover, England, one from Calais, France. They relied on GPS receivers outside the tunnel to check their positions along the way and to make sure they met exactly in the middle. Otherwise, the tunnel might have been crooked. Vehicle tracking is one of the fastest-growing GPS applications. GPS-equipped fleet vehicles, public transportation systems, delivery trucks, and courier services use receivers to monitor their locations at all times. The Global Positioning System is being used in another ingenious way; to guide people to their destination by way of a monitor in their car. Some car manufactures have added an optional GPS receiver in their new cars for a couple of years. All you do is type your desired destination in and the GPS gives you turn by turn directions, or a detailed map on a four inch video screen. A couple of new developments in the system have come about within the last year. First, the GPS receiver can tell you when your turn is coming up. Also, the Lincoln-Mercury company has added a refinement to the GPS-based safety feature. If you are driving and you need emergency assistance, just touch the ambulance icon and the RESCU (Remote Emergency Satellite Cellular Unit) system sends a voice activated cell phone call to the Westinghouse Emergency Response Center (Cetron and Davies 110). The center then dispatches police, fire, ambulance, or a tow truck to the location given by the GPS receiver in the car. GPS is also helping to save lives. Many police, fire, and emergency medical service units are using GPS receivers to determine the police car, fire truck, or ambulance nearest to an emergency, enabling the quickest possible response in life-or-death situations. In an interview for The NewsHour with Jim Lehrer, Spencer Michels points out that Air Force pilot Scott O’Grady, honored by President Clinton, provided the most dramatic use of GPS. He was rescued by American forces, after he was shot down by a Bosnian Serb missile over Bosnia in 1995. O’Grady used a hand held unit to find his exact position and radio it to rescuers before hostile forces could capture him. Mapping and surveying companies use GPS extensively. In the field of wildlife management, endangered species such as Montana elk and Mojave Desert tortoises are being fitted with GPS receivers and tiny transmitters to help determine population distribution patterns and possible sources of disease. GPS-equipped balloons are monitoring holes in the ozone layer over the polar regions, and air quality is being monitored using GPS receivers. Buoys tracking major oil spills transmit data using GPS. Archaeologists and explorers are using the system. Anyone equipped with a GPS receiver can use it as a reference point to find another location. With a basic knowledge of math and science, plus a hand-held GPS receiver, you could be an instant hero if you and friends got lost on a camping trip. Another interesting way people are using the GPS is on the golf course. A golf cart is equipped with a GPS System that knows exactly where you might be on earth and, there- fore, where exactly you might be on a golf course. Your own electronic caddie gives you all the vital information about play that a caddie would have given you in the past. Information about the course is a golfer’s best friend. “The key thing in golf is you want to know how far you want to hit your next shot, which determines your next club selection,” says Kathy Speight of Skylinks. Skylinks is a personal computer attached to a golf cart which tells you your position on the course in real-time. It also tells you the distances to hazards and holes with an accuracy of one yard. Other useful caddie-like information is given, like how far it is from the pin or the yardage to the next bunker. It also says when long is better than short. “In the past, you have to spend time looking for sprinkler heads and then pacing off how far in front or behind your ball is from that marker,” adds Speight. “With the Skylinks System, you can just look at the information, see your yardage, park as close to the ball as you want. That’s your reference point. Select your club and hit the ball.” The GPS antenna on board receives signals from satellites. And from this, the cart’s computer can work out its longitude and latitude on the earth. The accuracy at this point isn’t good enough for a golfer, so Skylinks has come up with something called pseudo-range correction. An antenna mounted on top of the cart receives a radio signal from the clubhouse, which has a more accurate, permanently based GPS station. Skylinks combines the information from this antenna to give us a system that is a hundred times more accurate than a standard mobile GPS. Using an on-board computer, its position is then combined with a program called Smart Map.

“Smart Map is a very detailed survey of every feature of the golf course — every tee, green, fairway, and sandtrap,” says Richard Beckmann of Skylinks. “Our position is then associated into the map and we know where we are relative to everything else around us.” As the golfer finishes at one hole, the Smart Map program is triggered to give you in- formation about the next hole that you’re playing. Every cart is monitored from the club- house using an RF radio link. Called Skyranger, it allows the manager to keep a close eye on the vital speed of play on the course. “We can go in and take a closer look at a few holes and take a look at exactly what’s going on,” says Beckmann. “Red cars indicate that there’s some sort of problem that the pro-shop manager would like to be aware of. So, if we go to the alarm screen, for example, we can dictate which cars we want to take action on.

The US Department of Defense developed the GPS system for the purposes of accurate navigation and positioning. It consists of both satellites and ground receivers, each of which perform well-defined functions. Four satellites must be used in order to determine the position of one ground receiver. The first three satellites are used to determine the position relatively accurately, and the fourth is used to synchronize the time clock of the receiver with the extremely accurate atomic clocks of the satellites. There are other measurement errors that come into play, but all may be quite accurately corrected for using various methods. In fact, the US Department of Defense purposely incorporates some “noise” into the system (which it is later able to decrypt) to prevent potential enemies from using GPS to develop their own weapons. GPS time keeping is used to set the clocks that regulate international communications and computer networks. These GPS clocks are used in banking for money transfers and bank time locks, among other things. They are also used for time keeping in certain scientific experiments. Most of the GPS manufacturers are not explicit about what kind of problems non- compliant GPS receivers will experience at the time of the roll over. Some of the problems could be:

1: The GPS receiver may not be able to locate the GPS satellites. In this case the receiver will not work at all. 2: The receiver may take a longer time than usual, possibly up to two hours, to locate the satellites. Having found the satellites it may or may not display accurate dates, times or positions. 3: The receiver may display an accurate position but the date could be as much as 19 or 20 years in error. 4: The receiver may display a position that is not correct. There have also been suggestions that particular problems will exist for some receivers during week 0, but that following week 0 they will operate normally. The GPS clocks will face the same kinds of problems with respect to dates and time.

The future of GPS is as unlimited as your imagination. New applications will continue to be created as the technology evolves. The GPS satellites, like handmade stars in the sky, will be guiding you well into the 21st century

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