I can’t tell you the precise latitude and longitude of where I was, but I do know that the city was Bonn, Germany and the year was 2007. I was lounging on my bed with a couple of my newest friends. We were gathered around a laptop because someone had suggested that we find our houses on Google Earth. A few mouse clicks later, I was showing off the playground that I frequented growing up. Next, I was familiarizing myself with a small town in Wisconsin. It was truly a bonding experience, and I was happy that satellite technology had brought my group of friends closer together. But for some reason, the word “creepy” also springs to mind as I reminisce. Pinpointing exact locations on the Earth so simply provides great advantages, especially when driving, farming, or taking part in military combat. There is also potential to abuse this tool, however, as it may yield invasions of privacy and national security breaches.

How GPS works
The Global Positioning System, or GPS, is a network of 24 satellites strategically situated in the Earth’s orbit. They are operated by the United States Air Force, which monitors them from five ground stations around the world. The data gathered are analyzed at the Air Force Consolidated Space Operations Center in Colorado (1). The first satellite was launched in 1978, but the system did not reach full capability until 1993 (1). While the technology behind GPS is complicated, its operating principle is quite straightforward: Each satellite continuously broadcasts a digital radio signal that includes both its own position and the time (to a billionth of a second). The receiver compares its own time with the time sent by a satellite and uses the difference between the two times to calculate its distance from the satellite. The speed of light is 186,000 miles per second, so finding just how far the light has traveled is a relatively simple calculation. By checking its time against the time of three satellites whose positions are known, a GPS receiver could pinpoint its longitude, latitude, and altitude to within a few hundred feet (1).

The ability to calculate time so precisely – to the billionth of a second – is possible because of atomic clocks within each of the satellites. Atoms absorb or emit electromagnetic energy in discrete amounts that correspond to the differences in energy between the different configurations of the elec-
trons surrounding their nuclei. When an atom undergoes a transition from one “energy state” to a lower one, it emits an electromagnetic wave of a characteristic frequency, known as the resonant frequency (1). These resonant frequencies are identical for every atom of a given element. A cesium atom, for example, with a resonant frequency of about 9 billion cycles/second, is often used in atomic clocks. In such a device, a beam of cesium atoms passes through an electromagnetic field that has its own oscillation frequency. A feedback loop adjusts this oscillation frequency so that it matches the resonant frequency of the element. This way, all the atoms can transition between “energy states” and absorb energy. At that point, the clock can use the newly-adjusted oscillation frequency of the electromagnetic field as a metronome to generate time pulses (1).

While the cesium-atom clock is the one utilized by the GPS satellites, research in atomic clocks has continued since they were conceptualized about sixty years ago. In fact, our nation’s main time standard is the atomic clock recently installed at the National Institute of Standards and Technology. Nicknamed NIST-7, it is accurate to within 1 second in 3 million years (1)!

Military Use of GPS
As the global positioning system was built by the Department of Defense, it was initially intended to aid the United States military in combat. One of the greatest challenges for soldiers in unfamiliar territory, where there are no identifiable landmarks, is navigation (2). They need to be able to track their enemies as well as guide bombs and missiles. To help with tracking, the army developed a GPS Truth Data Acquisition, Recording, and Display System (TDARDS). The TDARDS is a compact, low-cost, and mobile GPS-based tracking system that uses satellite data, radio data link, and computer technology to provide very accurate, real-time time-space position information on up to ten objects, including ground vehicles, helicopters, and other aircraft (2). Potential targets can be identified before they become dangerous. Also,
missiles that are commonly used by the United States to accurately hit targets from large distances use GPS receivers to accurately determine their location constantly while in flight (2). Most of the weaponry used by the United States military use GPS, either directly or indirectly, to accurately target and achieve the desired results. At the same time, GPS isn’t used solely to kill. When there are casualties or wounded soldiers, they can be rescued quickly because of this invaluable system. GPS can also provide precise maps of military bases to improve facility management (2).

Quite understandably, the Department of Defense was hesitant about allowing civilians to have access to this system. After all, it could potentially be misused – to aid smugglers or terrorists, perhaps. However, in 2000, under President Clinton, the government made a military-level accuracy of GPS available to all citizens. The White House is now committed to providing GPS services for peaceful civil, commercial, and scientific use worldwide and free of charge (1).

**Practical Uses of Satellite Technology**

We are all familiar with the convenience of having a GPS unit in a vehicle, whether it be our own or our cab driver’s. This very same satellite system is also behind Google Maps and MapQuest, virtual mapping tools that we have come to take for granted. Other - maybe less handy - uses for the global positioning system include: farming, mining, surveying, marine, and outdoor recreation.

For example, with GPS, farmers can combine their crop yield maps with soil survey maps, so that they only apply fertilizer to the least fertile areas. Otherwise, they would be forced to apply too much manure, resulting in a potential risk to themselves and neighbors from exposure to pesticides (3). “Precision agriculture” is the term used to describe this strategy, which uses information technology to make systematic decisions about farming, thereby cutting back on both the adverse effects of pesticide exposure (cancer, neurotoxicity, etc.) and on waste (3).

Another potentially positive use of GPS would be to help the blind navigate. A recent paper by the Visualization and Interactive Systems Group in Stuttgart, Germany explains how this would work: A GPS unit would first approximate the position of a building. Then the user would establish exact position at a specific landmark, like a door. This location would then initialize indoor navigation, using an inertial sensor, a step recognition algorithm and a map. Another inertial sensor would track movable objects. Additionally, a face detection algorithm could inform the user of the presence and position of other people (4). This system allows blind people to determine where they are with approximately 1 meter accuracy, and to navigate safely and by themselves, even in environments that they’re not familiar with (4)! Whether you want to get to the mall, grow some produce, or engage in outdoor sport, satellite technology is an extremely convenient tool.

**The Controversy Persists**

There is no evidence that GPS units and Google Earth are being used by terrorists, but people are still uneasy. Since Google Earth was released, it has received much attention from officials of several nations (5). They are alarmed that Google is displaying government buildings, military installa-
tions and other important sites within their borders with so much detail (5).

We enjoy high resolution images of landmarks, such as the Eiffel Tower, at the expense of many concerned world leaders. Lieutenant General Leonid Safzin, an analyst for the Federal Security Service, a Russian security agency, was even quoted as saying: “Terrorists don’t need to reconnoiter their target. Now an American company is working for them” (5).

But Google argues that they are not acquiring new images; the detailed digital photographs that Google Earth displays were gathered from other sources, which could technically have been accessed by terrorists and wrongdoers years ago. As John Pike, director of Globalsecurity.org, which has an online repository of satellite imagery, said – “If there was any harm that was going to be done by the imagery, it would already be done” (5). Also, these images are not updated very frequently, so while someone could potentially use Google Earth to determine where a military base was, there is no way they can count the number of aircraft or troops there are the present moment. And Google Earth’s powers are inhibited by a few restrictions. For example, United States law requires that images of Israel shot by commercial satellites are made available only at low resolution. Also, our nation’s government is allowed to put images of any area off limits in the interests of national security at any time (5).

Privacy Issues

Despite these restrictions, we need to consider the disadvantages of the widespread availability of GPS. When exploring its potential uses, it seems like the sky’s the limit - but where do we draw the line?”

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References


