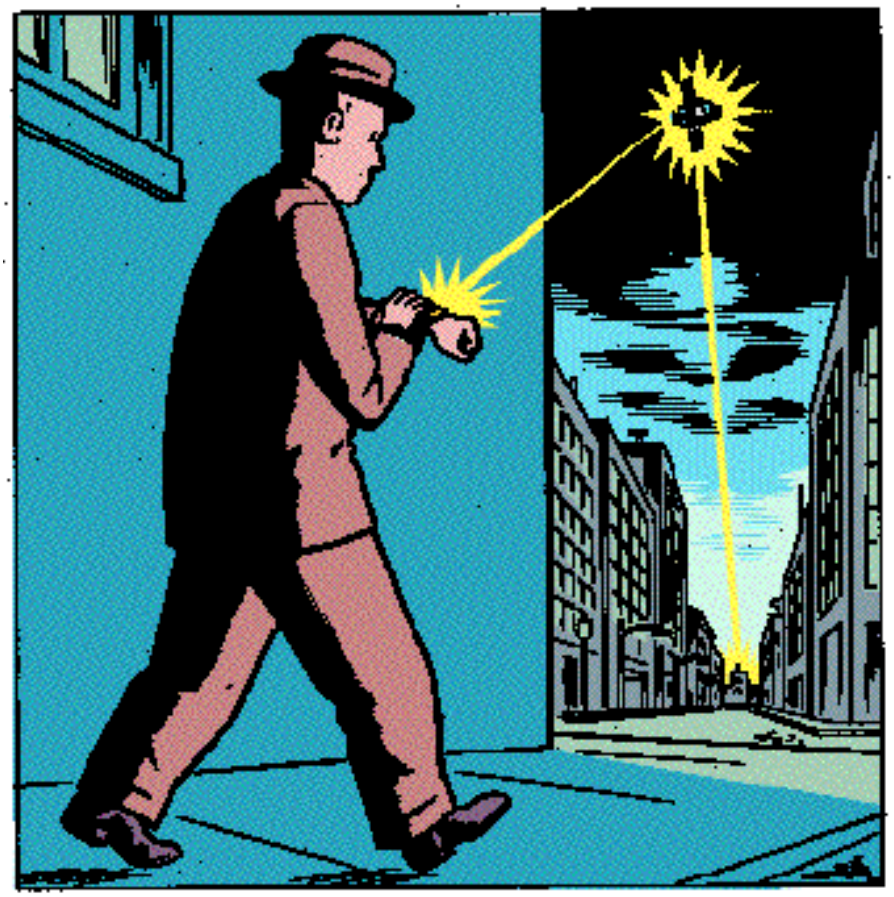
OUR FAR-FLUNG CORRESPONDENTS

NO PLACE TO HIDE

Why a satellite system may mean that we will never get lost again.

BY MICHAEL SPECTER



Soon every cell phone, watch, and laptop computer may come with a G.P.S. unit.

DAN CLOWES

I recently bought a compass that slips over the band of my wristwatch. It's the size of a dime, cost less than ten dollars, and was designed for people who ride mountain bikes into the wilderness. I don't own a mountain bike, but I do own many compasses. Right now, they are all lined up on my desk and pointing in the direction of the Vatican, just north of where I live. They work perfectly, and I find that comforting, although I am not sure why. Like many men I know, I am not very good about asking for directions, yet I rarely consult maps. Perhaps not surprisingly, I get lost almost everywhere I go.

As a reporter in Washington, I once got so mixed up as I raced off to cover a double homicide that I begged a taxi-driver to lead my car to the scene, just a couple of miles from my home. My family lived in Russia for several years during the nineties, and we had a dacha not far from Moscow. To get there required us to drive for forty minutes along a single well-travelled road; nonetheless, I managed, on several occasions, to steer in the general direction of Latvia.

All this came to mind a few weeks ago as I flew into Colorado Springs, a city that has quietly dislodged the North Pole as the most meaningful place on earth for the directionally impaired. Colorado Springs is the home of Schriever Air Force Base, where the 2nd Space Operations Squadron of the 50th Space Wing of the U.S. Air Force can be found. Its mission, with a little help from nearly a dozen cesium clocks and three hydrogen

maser oscillators (which were created to test Einstein's theory of relativity), is to control the global positioning system, the largest constellation of military satellites that has ever orbited the Earth.

Twenty-four satellites, along with four spares, circle the planet twice each day. They move in six orbital planes, placing, in effect, a giant birdcage around the Earth, assuring that there will usually be eight satellites in range. The satellites send out a constant stream of radio signals that contain information about their orbit and speed, along with the exact time. That allows them to deliver precise location information to anyone who has a device that can receive the signals. The receiver works like a radio: to establish a location, one need only turn it on.

The satellites function as reference points—the way stars once did for mariners—and not since the twelfth century, when the compass came into use, has a navigational tool promised to more fundamentally alter the way we live. Within a few years, every cell phone, quartz watch, and laptop computer may come with a tiny G.P.S. receiver embedded in it. In fact, by December 31, 2002, federal law will require cellular carriers to be able to locate the position of every user making a 911 call. That should eventually make it possible for emergency personnel to find anyone in America who calls 911.

Though there are earthbound means of complying with the new "E911" mandate, many carriers will rely on G.P.S. technology. The National Park Service is already using G.P.S. to map trails, keep their snowplows on the road, and even track bears. Air routes routinely have a geographical tag and so do coastal waterways and shipping lanes. It is even possible to rig a driver's air bag so that, as it is deployed, it activates a G.P.S. device that reports the car's location to the nearest ambulance. Our children may never fully understand the word "lost"—just as few people under the age of ten have any idea what it means to "dial" a phone number.

"Will you have a G.P.S. unit in your rental car?" Lieutenant Jeremy Eggers, the 50th Space Wing's press liaison, asked, reasonably enough, when I called from the airport in Dallas to tell him I was on my way. Although it is easy to rent a car with a G.P.S. receiver—places like Hertz add about six dollars a day to the cost and they provide voice narration that will tell you when and where to turn—I had forgotten to reserve one. Lieutenant Eggers sounded politely incredulous. Once again, I would have to navigate the back roads and scrubland of a place I had never been. I would have to look at that stupid compass on my watch and try to make sure I wasn't driving in the wrong direction. Lieutenant Eggers must have heard the distress in my voice. "This is a tricky place," he said. "The roads go on forever. People get lost all the time. Why don't I just meet you at your hotel and you can follow me out to the base?" Then he added, "Too bad, though. This is exactly what G.P.S. was invented for."

"Whose idea was this damn middle class?"

Originally, the global positioning system was not intended to help civilians at all. "The civils," as Lieutenant Colonel Daniel Jordan, the young commander of the 2nd Space Operations Squadron, calls them, came later. From the start, the system has been controlled by the United States military, which developed it soon after the Vietnam War. After years of watching soldiers become lost in dense jungles, the Defense Department wanted a space-based system to provide precise, three-dimensional position information that would also help its forces avoid detection. The Space Wing team guides the orbit patterns and provides all the data sent to every satellite. It also controls defense communications and the monitoring stations in Hawaii and the Kwajalein Atoll, in the Pacific Ocean; at Cape Canaveral; on Diego Garcia, in the Indian Ocean; and on Ascension Island, in the South Atlantic.

The first G.P.S. satellites were launched in 1978. In 1983, after Korean Air Lines Flight 007 was shot down by the Russian Air Force when it passed over the Kamchatka Peninsula—a Cold War disaster that might have been prevented if the crew had had access to better navigational tools—President Reagan decided to make the five-billion-dollar system available without charge to everyone in the world; that sent dozens of private companies scrambling into development. Still, G.P.S. didn't get its first great burst of public recognition until the Persian Gulf War, in 1991, when more than nine thousand handheld units were distributed to troops, letting them move about accurately in sandstorms, across the featureless desert, and at night. By the time the United States started bombing Serbia, in 1999, G.P.S.-guided weapons were allowing the military to attack targets accurately in adverse weather, and cheap commercial versions had become widely available.

Prices for G.P.S. circuits have fallen faster even than those for computer chips, and that has begun to transform a niche device into a common tool. For about a hundred dollars, you can find a G.P.S. unit that will tell you where you are almost anyplace on earth; the cheapest models are light enough to carry in a daypack, or even in a pocket. More complex systems come with color screens and detailed maps as full of facts as any atlas. Pi-

lots of small planes can purchase "terrain avoidance systems" that combine G.P.S. data with topographical information to keep them from crashing into mountains. Archeologists and fishermen and farmers rely on G.P.S. units. Land surveyors have abandoned the plumb and pole for the new technology. One of Russia's biggest banks has placed G.P.S. transponders in its armored cars, so that dispatchers can track their progress along the potholed streets of Moscow.

"I have been involved with G.P.S. since 1985," Matt Althouse, a space-systems analyst for the Scitor Corporation, an important technical consultant to the military, told me. "The first user set was up on a tripod with an omnidirectional antenna on top of it. It was about five feet tall and had a bunch of cables running to a big multichannel receiver, and it also had a tuner and a power generator. The whole thing cost three hundred thousand dollars. It was enormous. You look at that right now, at something comparable or better, and you can put it on your wrist. What cost three hundred thousand dollars fifteen years ago costs less than a hundred and fifty dollars now."

After G.P.S. was released to the public, military planners wanted to make sure that soldiers would receive more accurate signals than anyone else. So, in March of 1990, the government inserted subtle errors, or "noise," into the clock data that came from the satellites. Because the military wrote the codes, it knew how to compensate for the errors. The policy, called Selective Availability, was established to make sure that America's enemies would not be able to rely on G.P.S. to guide their weapons. It also meant that, while the Air Force could send missiles into windows in Baghdad, civilians would have to settle for signals good enough to let a helicopter find them on the top of a mountain. By this spring, however, researchers—not to mention foreign governments—had become so adept at using ground-based radio beacons to correct for the errors that the ten-year-old policy no longer held much value. On May 1st, President Clinton announced that the government would stop corrupting the signal. The change has already begun to have an immense impact on the industry, making devices more accurate and easier to use (and even cheaper: compensating for errors was expensive, requiring special software). Receivers that used to work to within a hundred metres are now accurate to under twenty—better than most topographical maps.

Lieutenant Colonel Jordan, who was dressed in a crisp blue flight suit, led me around the Master Control Station operations floor. To get there, authorized personnel must pass through the Entry Control Facility's booths, where they swipe their I.D. cards, are weighed, and enter a PIN number. Schriever Air Force Base sits like a lonely village in the flat plains east of Colorado Springs. "It's remote out here," Lieutenant Colonel Jordan told me. "You have to be committed. But we are. People get juiced from the work they do." They also get great technical training, Lieutenant Colonel Jordan added, and are regularly recruited by civilian firms.

He took me down a hallway painted in military beige, filled with signs admonishing people to be careful what they said. After walking by so many locked doors and warnings, I expected to find something out of "Fail Safe." Inside, though, it was a bit of a letdown. Apart from a model of the globe and the satellites that surround it, and the prominent "Top Secret" stickers attached to every computer monitor, "the pit"—as Lieutenant Colonel Jordan called the room—reminded me of a Citibank branch: it was big and blue, and had a large electronic Julian clock on the wall. About a dozen men were there when I visited—all of them clean-cut, inordinately polite, and young. It looked like the high-school science club.

Lieutenant Colonel Jordan asked me to sit at one of the monitors and introduced me to his crew, who were tracking the telemetry information that comes out of the satellites and making sure the solar arrays that power them were up and running. Every ten minutes or so, a new satellite would slide into range and the team would beam up coördinates. Lieutenant Colonel Jordan and his team explained that the computer in a G.P.S. receiver calculates its position by triangulation. To do that, the unit measures how long it takes for a radio message to travel from a

satellite. One satellite alone, however, won't do much good; it requires a minimum of three satellites, each one measuring my location from a different orbiting position, to tell me exactly where I am. Standing in the control room of the Space Wing, for example, I am eleven thousand miles from the nearest G.P.S. satellite. But I could be exactly the same distance from it if I were fishing in Siberia. "So you lock in a second satellite," Lieutenant Colonel Jordan explained, "one that is twelve thousand miles away." That would narrow my position to someplace in a circle covered by signals from those two satellites. But it's still a pretty big circle: I could be standing in the Space Wing or in front of the Sears Tower, in Chicago. That is why I would need a third signal, which would reduce the possible places I could be standing to two—one of which would be in outer space. A fourth satellite would allow me to determine my altitude. The more satellites in use, the more precise the information, and precision is essential: at the speed of light, clocks that are off by a billionth of a second would be accurate to within a foot; a thousandth of a second translates into nearly two hundred miles.

I asked one officer if he ever found such technical work dull. "Sir, I'm twenty-two years old and I am monitoring a system used by tens of millions of people," he replied. "The world is relying on us. So that is interesting to me." I nodded and started to walk away. Then he added, "We do other things here, you know, like watching for signs of the detonation of a nuclear device. That can be really useful, too."

I could see that G.P.S. would help people find their exits on the highway, and no doubt it will eventually make it less likely that my luggage will get lost. But calling it "a revolutionary tool of the digital world," as James Spohrer did when he described to me how ubiquitous G.P.S. would become, seemed a tad extravagant. Spohrer is a chief technical officer at I.B.M. and an eloquent advocate of the idea that once you have information attached to a specific place—once you put a geographical tag on nearly every spot on earth—the real world will start to get much more exciting.

Spohrer has written about a near future where it will be possible to walk into an unfamiliar airport, slip on a pair of glasses that contain a G.P.S. receiver, and watch as a virtual red carpet leads you to your gate. He is convinced that people will soon climb mountains and tour cities with devices that, connected to an earpiece or a handheld display, will tell them what they're seeing and how to find the nearest Chinese restaurant. Spohrer told me about an I.B.M. senior executive who has challenged his research team to develop a system that will use facial-recognition software, an earpiece, and, if needed, G.P.S. satellites, to whisper the name of any employee who walks by. "Sounds ridiculous, I know," Spohrer said. "Believe me, it's not. Devices that know where they are will soon be everywhere. And everything is going to know where it is. We are going to map every metre of this planet. And not just this planet, either."

I must not have looked convinced. "I'll tell you what to do," Spohrer said. "Go see Steve Feiner at Columbia University. Then let me know if you have any more questions."

One afternoon soon after that, I took the subway to 116th Street and Broadway and walked to the Computer Graphics and User Interfaces Laboratory at Columbia. Steven K. Feiner, a professor of computer science, is forty-eight years old and has slightly shaggy graying hair. His office looked as if it had been constructed as a set for a film about an absent-minded professor: laptops—whole and disassembled—digital cameras, special optics, and antique computer mice were everywhere. There were reprints of articles from the days when transistor radios were making news, and several bottles of Taittinger champagne sat on a table in the center of the room.

Feiner is Walter Mitty with a government grant. He works with technologies that take simple reality—such as basic information about where you live—add something to it, and make it richer. Feiner spends his time trying to blend G.P.S. computer graphics and wireless communication systems so that they all come together to enhance common experience. He asked me where I lived. When I told him Rome, he clapped his hands, leaped to his feet, and said, "Yes!"

He was silent for a moment; clearly, his mind had started to race. "You know," he began, "if you go to the Forum and look around, you quickly realize that the glory that was Rome is not amazingly

well reflected in the strewn pieces of column parts and what is left standing. It's a fabulous ruin, of course, but if you want to know what it was like you have to buy those little books that have old photos of Rome overlaid with the columns and buildings etched in their original form. That's not enough for me. I would love to go there without having to look at the artist's rendition. I would like to put on a pair of glasses and literally look around and go back in time. I want to see the buildings exactly as they were, maybe with pieces from contemporary life thrown in. I want the chariots whizzing by and the giant throngs in the streets and the markets full of whatever they sold. I want the fantasy and I want it to stop only as they are getting ready to throw me to the lions."

He sat down, and I wondered what this had to do with G.P.S. "As long as you can put a label on any physical object, on any building or monument or tree," Feiner explained, "you can take a pair of glasses with G.P.S. built in and with more sophisticated stuff which tracks the motion of your head. Those devices will know what you are looking at, so all you have to do is supply the software they need to tell you about it. That is what we are trying to do."

He picked up a pair of glasses with bluish anodized frames and small prisms embedded in the left lens. "We are not there yet," he said. "The system is heavy, it's unwieldy. I want it to be slick, like an MP3 player, and cheap. It's really just a question of time." Feiner led me across the hall, to his lab, where two of his graduate students were waiting with all sorts of gear. There were computer parts loaded onto a backpack, wall-sized monitors, and a large black device, resembling a stationary helicopter rotor, that helps track the movements of your head as you walk around a room.

"This work is based mostly upon the notion that there is someplace that you don't know but that you will be exploring," he said. "Maybe it's tourism or work or war, which is how we got into it. Much of my work is funded by the Office of Naval Research. It wants the marines and other soldiers to have all the right information: Where are the power lines? Where are the underground tunnels? Who might lie beneath the spot where I am standing, ready to blow me up? In essence, we are merging the physical world with the virtual world. We can label buildings with their names and show full-size 3-D models of underground tunnels as if they were being seen with X-ray vision."

Feiner has built a contraption that attempts to do all that. It consists mainly of the backpack computer—called "a real-time kinematic G.P.S."—which can pinpoint the location of a person to within several centimetres, and a visor that looks like a pair of good ski goggles. The first such system weighed forty pounds and the next one weighed thirty pounds. Now, with a computer powered by a seven-hundred-megahertz Pentium III chip, and a fast graphics card, it is down to twenty pounds.

As soon as I slipped on the headset, a

virtual version of the Columbia campus was projected onto my visor. As I glanced about, the gadget could tell which buildings I was looking at by monitoring the position of my head. Feiner loaded a documentary that he and some of his students had made, with the help of the journalism school, about the 1968 student uprising at Columbia, and through the visor I could watch film clips about some of those events, while standing exactly where they happened. Suddenly, when I looked off in the direction of Low Library, I heard the resonant voice of a narrator: "It was a sunny afternoon on Tuesday, April 23rd, in the spring of 1968.More than three hundred Columbia students marched to Morningside Park." As I turned my head to look at different buildings on the campus, Feiner's program presented film clips, sound guides, and bytes of history to go with whatever structure came into view.

The equipment may have been clunky and the images slightly cluttered, but it was hard to miss the point. "Today, if you go to a hotel, there will usually be a rack full of informational brochures—bus trips, museum guides, restaurant recommendations," Feiner said. "You can riffle through it to get some ideas of what to do. But,soon enough, it will all be in the chips. If you care about food, there will be different types of software; for antiques others. Pens and carpets and violins and wine will have distinct guides. It will be like the Internet. Whatever your interest is, somebody can attend to it.

"Falk maps are brilliant," he went on. "But they are on paper. I want the thing that does it all. Right now I am hungry. I am in Paris and I want to see all restaurants in the Nineteenth Arrondissement.Maybe it's a Monday. They need to be in close walking distance and open today. And do you know what? Instead of being told where they are, as I would in a guidebook, I want something to tell me how to get there, to just say, 'Turn left here and turn right there.' All I want is the directions. I certainly don't want to look like a tourist. No, I want to stroll confidently, like an arrogant Frenchman, in the direction of the restaurant. And someday I will."

There is a scene in the middle of "Mission: Impossible 2" when Tom Cruise injects a biometric chip containing a G.P.S. transponder into the ankle

of his leading lady, Thandie Newton. He is then able to track her no matter where she goes. It seems like boilerplate science fiction, but the day before Halloween, at Cipriani 42nd Street—a former bank turned restaurant that is now a palace of Old World ambience—a company called Digital Angel.net did its best to prove that it was not. The company demonstrated its new product: a global tracking system that can be attached to a person. The device has a tiny antenna that captures not only one's location but also such data as pulse and temperature and transmits it to an Internet ground station.

Richard Sullivan, the chairman and chief executive officer of Applied Digital Solutions (which owns Digital Angel.net), told an audience of journalists and others (including Norman Mineta, the Secretary of Commerce) that the chips, which are about the size of a dime, would not actually be implanted in anyone. They were for "external use only," he said, adding, somewhat ominously, that anything else was "purely hypothetical at this time." Sullivan also showed a short video that suggested how the chip could be used to find lost children or kidnapped executives or people with Alzheimer's disease who have wandered away.

A live demonstration came next: Somebody named Steve was driving back and forth along a road near the Long Island Expressway. His position and body temperature were transmitted through a G.P.S. chip and wireless technology to East Forty-second Street, where they showed up on three big video screens. At one point, Steve held the G.P.S. chip next to the car air-conditioner. The temperature reading dropped instantly. In theory, the chip could be coated in Teflon or titanium and then placed inside a body—human or any other. Digital Angel.net recently merged with Destron Fearing, a company that specializes in tracking wildlife and domestic animals.

"This is all very profound," Charley Richardson, the director of the labor-extension program at the University of Massachusetts at Lowell, told me when I called to talk about G.P.S. For years, Richardson has been concerned about unforeseen consequences of major new technologies, particularly for the labor force. "G.P.S. will change the workplace in definitive ways," he said. "Yet nobody even debates the value of that. It's something new, so we are just supposed to accept it. Right now you can drive down the Massachusetts Turnpike with a transponder in your car," he continued. "It signals to your account to deduct money for the toll when you drive through a booth. A G.P.S. transponder can do more, by informing the police where you are if you have an accident. But there is still more. It can also tell the police how fast you were driving. If you call in sick, should your boss be able to check your subway pass to see if you were travelling all over the city of New York? Are you ready for that? Because that's part of the revolution, too." ♦