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# Popular Science

## Here now: COMPUTERIZED NAVIGATOR FOR YOUR CAR

Electronic compass and motion sensor give pinpoint 50-foot accuracy


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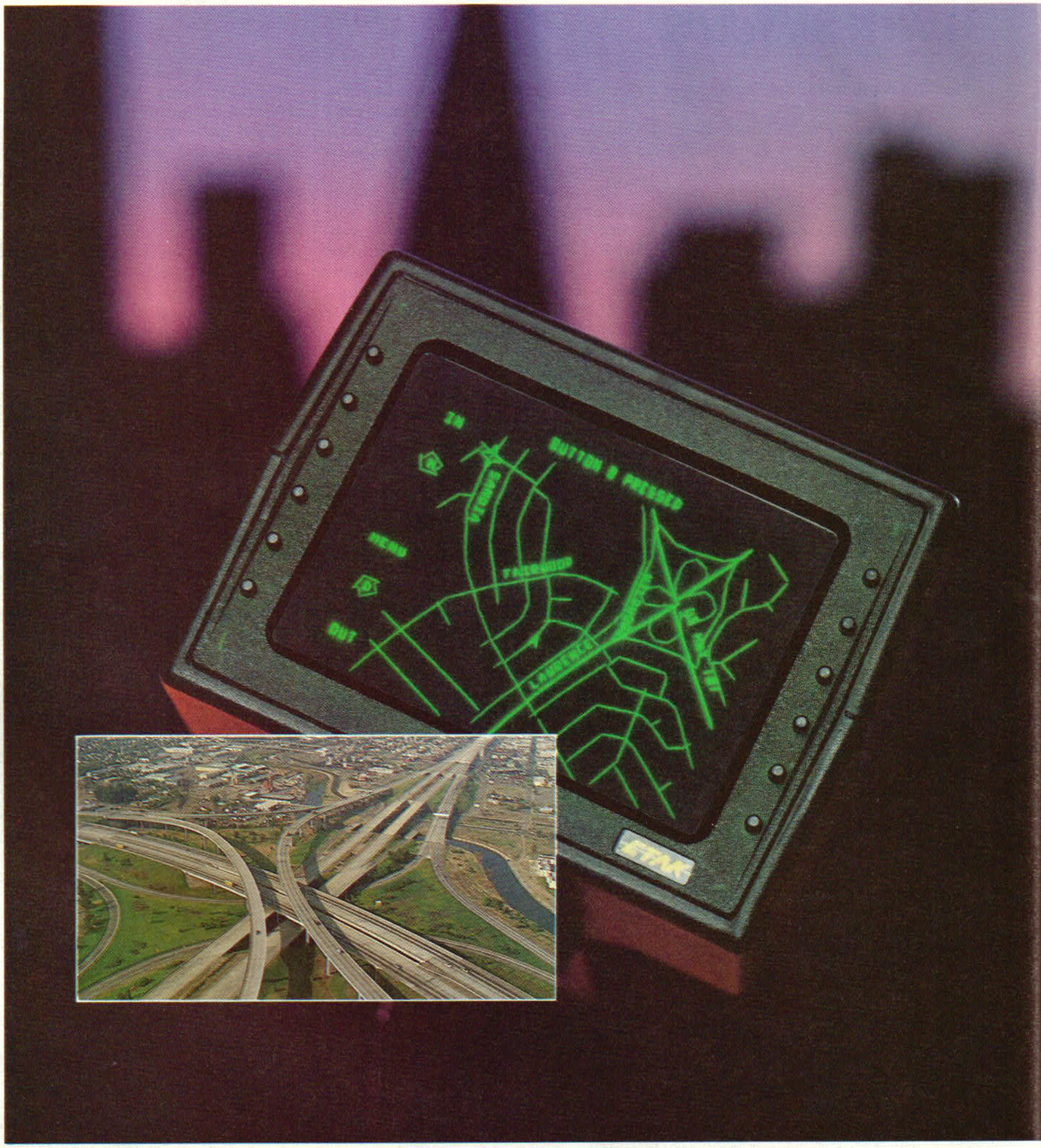

# d navigator for your car

A new auto navigation system provides a CRT with scrolling maps that accurately guide you to your destination. An electronic compass, motion sensors, and a "smart" dead-reckoning system constantly update your position to tell you, within 50 feet, where you are.

**By HERBERT SHULDINER**
*Color photos by Austin & West*

Usually, when I tell drivers how to get here," said Ken Broome jokingly in reply to my request for the best way to drive to his office in Silicon Valley, "I tell them to punch in our address on the car navigator and just read the screen." Broome, senior vice president of marketing at Etak, Inc., wasn't making such a far-fetched suggestion. After years of experimental work by others in many countries and the appearance of dozens of systems that were flawed or inadequate, his tiny firm appears to have succeeded where others have failed. Etak will begin selling car navigators this year.

By means of a CRT display showing a system of scrolling maps, the Etak Navigator steers you to your destination with an accuracy of within 50 feet—even after a journey of hundreds of miles. It's as easy to install as a car stereo system, Broome claims, and requires no training or calibration to use. It needs no external systems such as satellites or radar. Etak's navigation system is composed of a digital magnetic compass, motion sensors, and a "smart" dead-reckoning system. Together they determine where your car is at all times. A computer, equivalent in power to a home personal computer, is the brain. Etak's system lets you look at large areas at one time—even view the entire national interstate system—or zoom in so close that you see every street in your vicinity.

I recently spent a couple of days at Etak's Sunnyvale, Calif., headquarters with Stanley K. Honey, inventor of the Etak Navigator. I saw it being manufactured and got in some test drives in two different cars to see how well the system works on the road.

The idea that became Etak was born a few years ago when Honey was serving as navigator aboard Nolan Bushnell's racing yacht. (Bushnell is the founder of Atari and the inventor of Pong, which started the video-game revolution.) Honey, now Etak's vice president of engineering, designed a navigation system using Loran C that was installed in Bushnell's yacht. Using this system, Bushnell won two Trans-Pac races (from Los Angeles to Honolulu).

## From ship to shore

During one of the long voyages, Honey had a new idea: an auto navigation system based on a system that would not require Loran C radar, which can encounter much interference on land. Bushnell had enough confidence in the idea to put up seed money for Etak in May 1983.

Then Honey had another idea based on his yachting days. He knew from his studies of navigation history that the Polynesians navigate vast distances of the Pacific without instruments. By thinking of their canoes as stationary and the islands around them as moving, they measure their traveling distance by the "movement" of the islands. They call this system *etak*.

Honey applied the same idea. He conceived of a CRT display with the car stationary in the middle of it. The map would move as the car got underway. Naturally he called the system Etak, and the company was born. Work went rapidly. "We had a working prototype ready within six months and were navigating the streets of this town," Honey told me.

Then design work on the two production models began. When I arrived in Sunnyvale, a pilot line was already assembling some units. I had a chance

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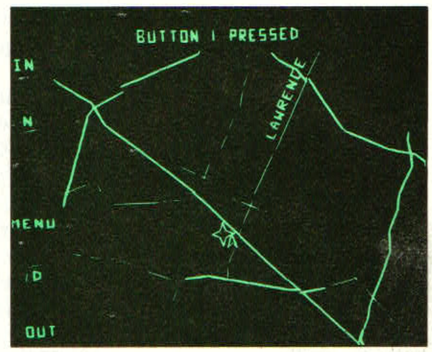
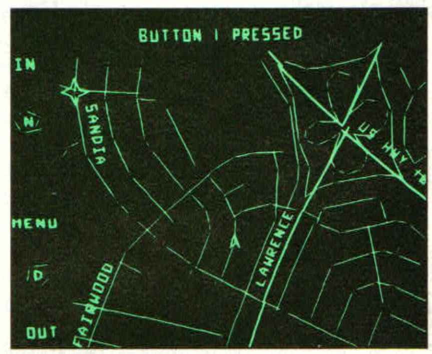
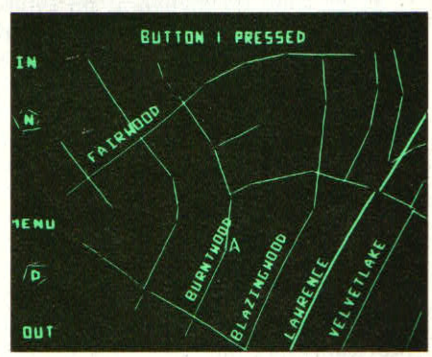
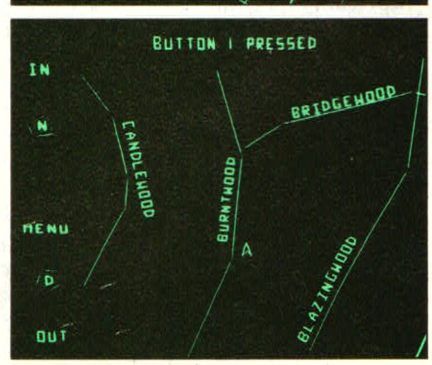



**Zoom capability of Etak Navigator is shown in photos at right. In most-zoomed-in mode (top), map displays only 1/4 sq. mile. Every street is labeled. As you zoom out, less detail is shown—until only major arteries are displayed. Zoom is only control that can be operated when car is moving.**

to test two of these early-production navigators.

### Hands-on navigating

My first experience with the Navigator began with a demonstration ride with Don Warkentin, Etak's marketing director. After instruction from him, I was able to select a destination by myself.

"You don't have to spell the whole name," Warkentin told me. "Just put in the first three letters of the street intersection you want to drive to."

I selected the letters using the "Speller" button next to the CRT. Then I hit the "Select" button, and the screen immediately displayed street names beginning with those three letters. Using another button, I scrolled through the index to find the street I was searching for. (Destinations can be entered by street address or by intersections.) It took me only about 90 seconds to find my intersection and enter it in the Navigator. Now a map appeared on the screen, and a flashing star showed up at the location of our destination. Our car was represented by a stationary triangle in the center of the map. Using these symbols, it was easy to pick out the best route. As we drove out of the parking lot and turned onto the highway, the map started to scroll, keeping the flashing destination star always ahead of us. The streets, as shown on the map, precisely matched the view through the windshield as we headed in the direction indicated by the flashing star. The symbol for the car itself stayed in the center of the map as though glued there.

Every time we turned at an intersection, the map changed directional orientation. In addition, it showed the vehicle exactly at the intersection, going onto the road onto which we were turning. Honey later explained why the navigation system is so accurate: "The system works on dead reckoning—maintaining a known position through measured courses and distances traveled.

"Still, in dead reckoning, no matter how good your sensors are, they inevitably accumulate error as you drive," Honey said. "What we do is use comparisons with the map data base to recalibrate the sensors, as well as to eliminate the accumulation of error." In the Etak navigation system this happens once every second as you drive. The computer in the Navigator constantly compares distance measurements to distances on the map. If they disagree—perhaps the display shows you making a turn just short of an intersection—it ignores that, for the moment. But when you make the next turn, it will move you to the correct position because the "smart" dead reckoning figures out that you must be at the right spot.

**Seven-in. display of model 700 Navigator (above left) is for commercial or government users. Model 450, with a 4½-in. screen (on flexible stalk), is one most passenger-car owners would select. Both models use the same tape**

"We've been referring to it as augmented dead reckoning," Honey said. The secret is the navigation algorithm he has invented. An algorithm is a step-by-step set of instructions that makes up a computer program.

Honey cites this example of Etak's augmented dead reckoning: "Suppose you've driven around a particular S-bend, and in the map data base there happens to be a road with an identical S-bend—but the map shows it a few feet over from your position. Well, you'd decide that you're probably on that section of road." That's exactly what the computer does to eliminate accumulated error.

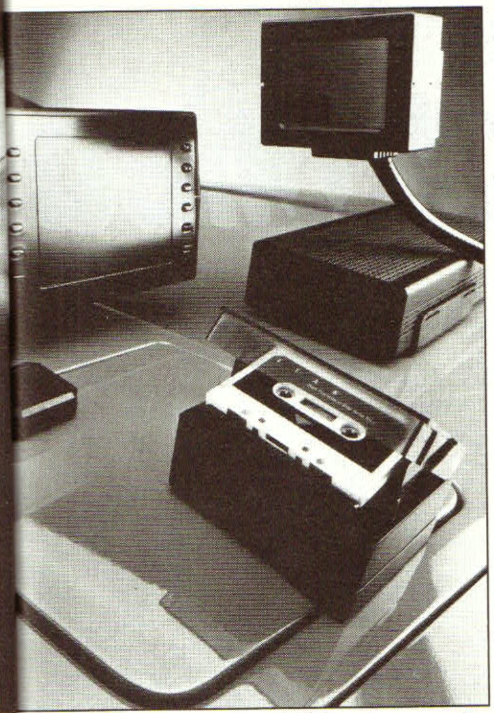
### Lost on the straightaway

Does the computer ever get fooled? I was shown how it can get crossed up on a ride the next day with Chuck Hawley, Etak's digital-map-production manager. The navigation system's greatest accumulation of error occurs on long stretches of very straight roads, Hawley told me. The reason? The computer needs turns to keep it oriented. (It ignores mere lane changes.) If you're driving straight stretches of road, it has nothing to go on but the compass heading and the measurement of distance by the motion sensors.

The sensors scan strips of magnetic tape mounted on the inside of each of the non-driven wheels. The tape has alternating positive and negative magnetic areas. Once calibrated during the initial system installation, the sensors count wheel revolutions to get a precise measurement of distance. On roads with curves and turns, the computer uses its augmented-dead-reckoning capability to reorient itself. Straight roads give it no opportunity to correct itself.

Hawley showed me how it works. After a straight run of several miles, we were about 30 feet off on the map. But amazingly, after a couple of turns, the vehicle's position appeared right where it should be. If it hadn't, it would have been simple to reposition our vehicle on the map, as Hawley showed me, by moving the car cursor with a button control. It can be done quickly at any stoplight.

Inaccuracy can also creep in through tire-pressure changes or tread wear, which can change apparent wheel size. And there's a need to reposition your vehicle if it ever gets "blindfolded," Ken Broome said: "If your car gets towed or you take a ferry ride, the car probably won't know where it is when you get back on the road." There is no non-volatile memory in the system. Instead, a low-drain complementary-metal-oxide-semiconductor random-access memory stores the vehicle's position. The Navigator draws only one milliamp



drive (above right). Solid-state magnetic compass is shown under large-screen model in center photo; electronics package is in box under the small model on flexible stalk. Compass and electronics can be hidden from sight.

of current when the ignition is turned off. When the system is turned on, it draws about 40 watts—about the same as a headlight.

## Easy reader

I found the Navigator simple to operate, and safe. The street names are legible enough to read without leaning over or squinting. Photographers Jeff Austin and Jim West, who sat in the back seat during my first test ride, had no trouble reading the screen from their position.

The only time I had trouble was when the sun was at the back of the car and shone directly on the CRT, making it impossible to read the map. Etak is planning to brighten the screen to overcome this problem, according to Hawley.

When you're driving, the only control that works is the zoom operation. But the zoom feature is useful. You can zoom in so close that only a ¼-mile area is shown on the entire screen. This gives you a view of every street and street name in an area. You can then zoom out so only major roads are shown—and then all the way out to the interstate system. If you zoom in so close that your specific destination is no longer shown on the map, a flashing arrow appears and points to your destination. The same arrow appears if you drive out of the map's area of coverage. At the same time, a message appears on the CRT instructing you to insert a new cassette to cover your area. Etak engineers decided it could be hazardous to select destinations or reposition the car while it's in motion, so those controls won't work when you're moving.

You don't lose the display on the screen when you change cassettes because the Navigator's computer has 256 kilobytes of memory. This is enough to maintain a map of the area surrounding the car while you change cassettes.

Honey is proud of the hardware package he has put together for the Navigator. There are only a few customized components in the system, he says. It contains mostly off-the-shelf components; that's one reason he was able to put it together so fast. But Honey is even prouder of Etak's unique digitized data base—that is, getting maps into a digital form stored on magnetic tape that a computer can use to generate maps on the CRT.

"When we began, we thought this would be the easiest part for us, and we'd just go out and buy digitized maps," said Honey. But a thorough search yielded nothing. Nobody had ever done such a job. This put Etak in the cartographic business in a pioneering way. The company started with materials in the public domain: U.S. Geological Survey maps, county-engineer maps, Bureau of the Census files, and aerial photographs.

The company devised a unique way to digitize the data. "Turning all this information into digital format would have been prohibitively expensive and time consuming using normal techniques," Honey said. "In the past, you'd lay the material out on a big digitizing table and then take a mouse or cursor and move it around over the original art.

"We developed a patented automated way of doing this task," Honey told me. But he wouldn't give specifics: "That's one of our biggest secrets." The process involves laser scanning and computer translation of source material into digital information. An editor then uses a mouse to touch up the maps and make corrections.

## Etak in the marketplace

Etak plans to start selling two models of the Navigator this year: the 700, with a seven-inch screen ($1,595), and the 450, with a 4½-inch screen ($1,395). Map cassettes will cost approximately $35 each.

Sales will be through car-stereo and land-mobile- and cellular-telephone dealers. The company does not plan to sell direct, except perhaps to large fleet users.

Broome estimates that installation of the Navigator, which takes two to three hours, will probably cost $100 to $200. The same dealers will do the initial calibration of the system. Repairs, however, will be performed only at the factory.

Who will be a likely customer for the Navigator? Broome says potential customers include anyone from the more than 12 million persons in the U.S. who use their cars for business. Salesmen, executives, and lovers of new gadgets are among prime candidates. Rental-car companies are also prime prospects; Etak is negotiating with one now. The company is also talking with some big companies, utilities, fire and police departments, and other major fleet owners.

The market for Etak Navigators may be further expanded with a new project the company has in mind. Now, cassettes contain only maps. In the future it plans to offer cassettes with "yellow page" directories. The cassettes would help you find hotels, restaurants, service stations, roadside rest areas, and certain types of stores. In fact the possibilities are so vast that the company doesn't yet know all the areas it will enter into.

Also, Etak is negotiating with some large fleets on a route-planning system for dispatching vehicles. Further down the road is a two-way system that would allow a dispatcher to see the location of every fleet vehicle on a large display board. PS