



## TWENTY-FIRST-CENTURY TRAFFIC TECH

Imagine this: you set out to drive across town to meet a friend. Before you start, you pull up a map of the route on your car's navigator. Anticipating the traffic expected during the next twenty minutes and the approximate duration of the drive, your navigator suggests a route that should be the least congested. You click to accept the route and follow it to your destination without incident.

Once you arrive, LED signs on the street point you toward blocks with available parking and alert you to the nearest recharging station. Wasting no time circling the area, you slip into a free spot, plug your car into the post, lock up, and use your phone to pay for two hours of parking and charging.

This scenario is not so far in the future. Spanish companies, which have achieved international prominence in traffic planning and modeling, tolling, lighting and signage, and guidance systems, are harnessing the latest technological advances, working to create this reality in cities around the world.



## KEEPING IT ALL MOVING

As urban populations continue to grow, traffic pressure on existing roads and highways increases, although many cities in western countries have expanded their built environment nearly to the limits of what is possible. City and national managers are also concerned about pollution and global warming: urban traffic contributes up to 40 percent of a city's carbon dioxide emissions, and about 70 percent of other pollutants, such as nitric oxide.

In response, says Rafael Morán, Madrid's associate director of traffic and planning, "We first need to convince people to use public transportation . . . . And then we have to facilitate the movement of vehicles."

Adds Pablo Barceló, COO of Barcelona-based Bitcarrier, "The only alternative is optimization" of current roads, "to make better use . . . of the infrastructure that we already have," in order to avoid increasing traffic and to reduce emissions from idling. To accomplish this, Spain's Traffic Authority, part of the Ministry of the Interior, has invested significant funds in intelligent transportation systems (ITS) over the past twenty years.

Communications and computing power are already altering the way we drive. Cell phones and GPS navigators send out signals that allow managers to monitor the volume and speed of cars on the road. And the movements of buses, cars, and trucks are

monitored in real time, with drivers alerted by their on-board navigators and by roadside signs to the best routes to take to avoid snarls. Systems like these, which employ the tools of the high-tech economy to keep traffic flowing, are some of the latest examples of ITS that are starting to enter the market.

In order to speed up city bus rides, Grupo Cegasa, headquartered between Bilbao and Pamplona (specialists in providing road signs called variable message signs and communications among those signs, vehicles, and control centers) is developing a technology to give traffic preference to buses, controlling access in special dedicated lanes. A GPS onboard a bus communicates its location to a central computer in a control center, which relays that location to traffic lights. The system monitors the occupancy of the dedicated lanes so when the bus approaches a signal, the signal remains green long enough to allow it to pass.

To manage the flow, traffic controllers, sitting by screens that show a scattering of city roads, need access to real-time information about the location and speed of vehicles all around the city. One of the most significant changes that supports this effort is the use of travelers as information producers, rather than simply information consumers. "All the systems [in use, such as mobile phones and GPS systems with Bluetooth con-

nections] are generating huge amounts of information,” says Francisco Cáceres, chief technology officer at Madrid’s Telvent.

And Bitcarrier is one of the first two companies in the world to commercialize a product that picks up on these signals to count vehicles on the road.

## COUNTING WITH SIGNALS

Today, traffic counting is generally accomplished by using inductive loops buried under the road, which register the magnetic interference of cars passing over them; since this is expensive and time-consuming to implement, few intersections can provide this critical information. Though other technologies for continuous traffic counting have been developed, they are too expensive to be widely used.

Bitcarrier’s founders believed they could devise a method to capture the public Bluetooth signals that emanate from consumer products, each with an individual signature. “The signals are public—you cannot track the person—but you can track the device,” says Barceló.

To date, in most Western countries, about 30 percent of cars and trucks—or their drivers—are equipped with a smart phone or GPS system. The proprietary sensor that Bitcarrier has developed can be hung from a traffic light or lamp post and plugged into a socket with no additional infrastructure, and it can pick up the signals from equipment that passes within approximately 120 feet.

This equipment collects data about both the number of vehicles on the road and their average speed, as the sensors can monitor when specific signals pass multiple sensors. Wireless transmission directs this information to a central computer, where highway managers can use it to notify drivers about congestion and driving times ahead. The system can also alert operators immediately to traffic jams from accidents.

This idea was conceived four years ago, and for the past year and a half Bitcarrier has been creating the device and testing its accuracy. In February 2010, after an eight-month trial period, the transportation concession Abertis Infraestructuras—which operates toll roads in Spain and other countries—bought 150 units to monitor traffic on a major Spanish highway. Abertis has already announced that it will purchase additional units for other roads. The city of Zaragoza, in northern Spain, has decided to blanket the city with these sensors to capture nearly 100 percent of city traffic flow information, and inquiries are coming in from around the world.

## PHANTOM TOLLBOOTH SYSTEMS

Traffic traditionally slows to a crawl at tollbooths. To counter this, companies and cities have been using onboard tags that allow vehicles to drive through without stopping. The advanced information systems and systems integration company Teccsidel, which designs and supplies tolling systems around the world, is one of the few international companies that has moved beyond barrier-free tolls

to create an open tolling system. In this system, implemented by Teccsidel in Oslo and elsewhere in Norway, cars continue moving at normal speed when approaching a toll; the toll scanner stretches over the highway like a traffic signal. This can save fuel by preventing traffic jams, and the scanner can be installed rapidly without major remodeling of the road.

As vehicles zoom underneath the apparatus, overhead cameras pick up a vehicle’s image at speeds up to 120 mph (200 km/h). If the vehicle has a tag, like an EasyPass in the U.S., the user is charged automatically. Otherwise, the license plate’s image is captured and deciphered by a software program that then sends a charge to the driver.

“Everything is based on the quality of the pictures,” says Gerald Pelle, Teccsidel’s marketing director. “It’s a mature technology, but there are still limitations: if there’s a lot of snow or dirt, the license plate is not even readable by human eyes.” The Teccsidel apparatus captures both front and rear plate images to minimize such challenges.

Today there’s a trend in some places—Portugal, for one—to equip cars at purchase with ID tags, similar to license plates, that can facilitate country-wide free-flow toll systems. Madrid-based Indra Sistemas, a world leader in information and communication technologies, with projects in more than 100 countries, will introduce the first such automated toll system in Portugal, on a stretch of highway that runs north to the Spanish border. Indra’s payment platform can handle up to 1.5 million transactions a day.

Indra integrates technologies that are available on the market into complete systems, marketing them throughout Spain and in Europe, Asia, and the Americas. Indra manages ITS for nearly 2,500 miles of Spanish highways and controls toll lanes and plazas in 15 countries. Leveraging their defense experience, Indra engineers have developed a product that capitalizes on radar technology from Spain’s Department of Defense to provide a more advanced radar system for civilian roads.

Indra is one of a number of systems integrators (which include major international companies such as Telvent and Sice) which develop their own products in house while also integrating available technology to present a cities or regions with complete traffic management. Telvent supplies intelligent systems that control traffic at more than 9,000 intersections a day, and toll networks that handle 1.5 million vehicles annually; its clients include the New York State Department of Transportation and the Municipal Corporation of Greater Mumbai.

Sice integrates complete highway solutions in Europe, Latin America, and North America, and at times operates highway road tolls as a concessionaire standing in for a public authority. In Melbourne, Australia, “we’re capable of managing 8 million transactions a day [in tolls],” says Angel Aguilar, Sice’s international director.

According to infrastructure director Vicente Sebastián of Grupo Etra, which provides integration service to cities such as Madrid, his company’s goal is “to optimize the hardware with the



## VIRTUAL VALET PERFECTS PARKING

Cities often frustrate drivers in search of parking; cars weave through city blocks, wasting time and burning gasoline. Parking cars quickly could improve mobility and help cities meet environmental goals of reducing carbon dioxide and pollution.

What if drivers could be directed to available spots immediately upon arrival at their destinations? Parking efficiency possibilities have inspired Barcelona-based ParkHelp's directors, who originally founded their company to focus on embedded electronics connected to the Internet. That work morphed into a successful project creating the parking guidance system for Madrid's new ten-thousand-space airport parking garage, one of the largest such systems in Europe.

ParkHelp engineers designed proprietary sensor holders, which use no screws, and built their own cables, eliminating most connections, creating a system that can be easily and quickly snapped into place.

Sensors communicate the occupancy status of each space on a given floor to an independent processor on that floor. The floor processors communicate with each other and with a central computer. "When we finished, the result was the most complete project available on the markets for airports and projects of this size," says company cofounder Alexis Puig: the company has since won contracts for similar projects in 22 countries.

In 2007, ParkHelp decided to try to create something that did not yet exist. "We said, let's see how our successful experience in parking [garages] can translate into parking in the city," said Puig.

First, company engineers needed to identify the best sensor available, one that uses little battery power. They decided on a new technology that operates by registering the earth's natural magnetic field, then sensing when it's disturbed by a huge amount of iron—a vehicle—in that field.

Once alerted to the presence of a vehicle, the sensor sends the information to a control center. That computer aggregates the vehicle information and automatically updates LED signs to alert drivers to available spaces.

In the future, this information will also be uploaded to a website, even directly to a car's GPS. "You'll be able to program in to your GPS, 'I want to go to this area of the city,' and when you get there, it'll direct you to a parking spot," predicts ParkHelp cofounder Ignacio Maluquer.

A prototype system very like that has already been set up in Lleida, a city of almost 40,000 just north of Barcelona, and will soon be available in other Spanish cities, including Malaga and Madrid. Cities around the world have expressed interest, in part due to the clear environmental benefits. But beyond that, the return on investment for cities or companies that manage city parking happens quickly, say company directors, because drivers pay for the parking time they occupy, the turnover is rapid, and infractions are easy to enforce.

most efficient use of energy, at the least cost, and integrate” all the elements of a complete system from different manufacturers. In addition to integrating services, the company develops and manufactures the core computer systems they deploy. They’re working on a novel means of communicating with the public: in Madrid, they’ve designed a system whereby riders can send a text message with the bus number and stop identifier, and immediately receive back a text with the arrival time of the approaching bus.

## PREDICTING TRAFFIC

In an ideal world, traffic managers need to peer into the near and distant future to evaluate traffic control options. How will a road closing affect vehicle flow, and what are the best routes for redirecting cars and buses? When an event such as an accident occurs, what are the best diversion plans to facilitate movement?

Tekia Ingenieros (Tekia), based in Madrid, has been tackling the planning for traffic control in tunnels. The company’s most ambitious project to date involved analyzing the safety needs of the newly built tunnel section of one of Madrid’s ring roads; it is buried under a river, and the tunnels stretch out for more than 30 miles (50 km), making it the world’s longest underground automobile traffic structure.

Tekia engineers looked hard at potential safety threats to the tunnel, such as heavy traffic, or accidents, fires, or explosions. They brought together a roundtable of security experts for a year. Using all the expert information and possible scenarios gleaned as part of their program, and aiming for the best outcomes for each scenario, Tekia then built an expert operating system to help a city planner decide in real time which solutions would best solve problems that arise.

Such traffic modeling software is the specialty of Transportation Simulations Systems (TSS), a Barcelona-based traffic modeling company offering more than 25 years of experience helping cities plan for traffic flow.

TSS developed its modeling program, Aimsun, using research performed at a Barcelona university. At the time, in the 1980s, company founders realized that the big-picture regional models that were being used for strategic planning might be able to predict population and traffic growth on a large scale, but were not much help in determining the best solutions for small-scale changes in traffic.

Company engineers wanted to create a model that could examine behavior on the micro level. “What will happen if there’s road work on a major arterial that also has a tramway and lots of traffic? You can experiment with adjustments to make the situation more tolerable—maybe change the light settings, restrict access to some roads, or send the police out to direct traffic,” says Alex Gerodimos, TSS commercial director. Despite the much lower computing power available at the time, TSS’s new models were able to accurately predict the results of interventions on this more modest scale.

But while this was helpful for planning, these models could not yet assist real-time traffic management. Since then, leaps in

computer processing speeds, coupled with the greater quantity of real-time information now available on the details of traffic flow, have allowed a revolution in modeling: TSS and its partners have developed both small- and larger-scale Aimsun models that can be used by city traffic managers to determine the consequences of changes to traffic in real time, allowing them to make rapid decisions based on predictions from the models.

For instance, an ambulance might need to reach the scene of an accident, but that accident has already caused changes in traffic that are rippling outward. The models can provide images of the possible ambulance routes and suggest which will be the fastest.

In Madrid’s municipal traffic control center, the graphic simulations hover on a screen, allowing the controller to visualize the consequences of particular choices 10 to 20 times faster than they would occur in the real world. The Aimsun software used here is used to model traffic for other cities in 60 countries, including the entire nation of Singapore.

Telvent uses a modeling program for its control systems, and has been able to incorporate weather and pavement conditions into the traffic management systems for cities such as Alberta, Canada. “We can use weather information for precise support. For instance, we can predict what the pavement conditions will be over the coming hours,” says Cáceres.

## SMART INFORMATION FOR SMARTER TRAVELERS

Drivers today can take a quick glance at a number of web pages that claim to show current traffic conditions. “We believe this information is inferior—or in some cases useless,” points out Gerodimos. “It’s often based on what we know now.” But if the information is not available, because a particular road isn’t monitored for traffic, it appears traffic-free, no matter what the actual conditions. A model can solve that issue, he explains, by extrapolating for the entire city.

And the second problem, he says, is that the driver hasn’t left the house yet, and traffic may change rapidly. Gerodimos envisions a future in which predictive models will be available not just to traffic control managers, but to consumers as well. With software such as Aimsun running, the car’s GPS system could not only offer current traffic conditions, but recommend the best course for a 30-minute drive based on future traffic patterns.

“If we provide consumers with smart information about options for mobility, we’ll improve both mobility and the efficiency of the infrastructure,” explains Telvent’s Cáceres.

Supplying easily accessed information is the goal of the system designed by Telvent for New York City, San Diego, and Tennessee. It relays real-time information on traffic and public transportation via the Internet. Citizens can also dial 511 to listen to up-to-the-minute responses provided by a computer-generated interactive voice response system.

Today, many consumers receive information about traffic when they're in the midst of it, on the road, through brightly lit displays called variable message signs. These signs—typically LEDs—look simple, says CEO Tony Batlló at Imago Screens, one of the top LED sign manufacturers in the world for traffic and for events such as sports. “In reality, the needs for traffic [as opposed to sporting event screens] are much higher,” he continues. “They need 100 percent security, functionality, and performance, 24 hours a day. The reliability is crucial.”

The LEDs themselves form the base of the signs, and company engineers then carefully design the optics and the control systems to specific brightness, contrast, and luminosity, depending on the sun conditions in a given country, and even on a given day. “It’s important to be able to see the sign clearly,” says Batlló. “But if it’s too bright, then it hurts your eyes and you can’t read it.” Sensors built into the screens detect the light conditions and modify their brightness automatically.

The sensors on the LED panels can offer additional information to road managers. “The panel can be programmed to tell the controller, ‘It’s raining; do you want to display a message about rain?’ The operator can say yes or no,” explains Batlló. “In the future, roads will have devices that can communicate with each other in a kind of network, with cameras, sensors, weather stations, and a network of information that will include even the user’s vehicle on the road.”

## NEWWAYS TO NAB BAD DRIVERS

As recently as 2005, Spain had one of the highest numbers of accidents per person in western Europe. Through the use of new technologies, the country managed to reduce deaths dramatically: “We’ve gone down by more than half in less than five years,” says Alberto Arbaiza, in charge of ITS projects at the Ministry of Interior’s Traffic Authority.

In speed management, standard techniques until now have relied on fixed locations, either a cop with speed-catching radar or a signpost that flashes a driver’s speed as he drives by. The challenges presented by these fixed positions is that it’s relatively easy for a passerby to slam on the brakes and then immediately hit the accelerator.

To replace them, Grupo Cegasa has developed a system of what’s known as *section speed*. This technique works by capturing a car’s position first at one location, then at a second one down the road, then calculating the speed that it took to traverse that segment. The license plate numbers of speeders are captured and sent to the authorities. “This is not only an alternative way to measure speed, but it’s also safer, and more fair,” says Alfonso Vazquez, international sales director, and it slows the overall speed of the traffic.

Traffic accidents are also caused by drivers hurtling through red lights. Today, the latest technology at intersections involves an inductive loop under the street; as the light turns red, a car passing over the loop triggers cameras that capture the car’s

image. Barcelona-based Quercus Technologies recently unveiled the first system in the world that operates on a small moveable system of cameras, which works independently from traffic lights or traffic controllers.

Quercus has built on its experience in artificial vision—they’re one of the top producers in the world of license-plate recognition systems—to create a noninvasive technology. “It’s what we call virtual loop technology,” says Silvia Vilanova, Quercus marketing director. “All the recognition you need is in the camera and you don’t need any sensors in the road.”

The camera faces the light and picks up on the location of light emanating from the signal. When the light changes from green to red, the position of that light changes, and it triggers the camera, which snaps a series of shots as the car traverses the intersection. This product, launched in March 2010, has a number of added advantages: it is significantly cheaper than the alternative, and it demands no additional street work. In addition, research has shown that after the implementation of a system to capture transgressors at a light, that particular intersection becomes safer within a year or two. But the traditional loop-based infrastructure is prohibitively expensive to move. Quercus’s camera, however, can be readily lifted and recalibrated to the specifications of a new intersection.

## HELPING TRANSIT SEE GREEN

To help transit systems communicate with public transportation users, Tekia engineers developed a system of predicting bus arrival times based on on-board GPS systems. They soon realized that the equipment could be enhanced to contain more than just a GPS unit, and could provide information beyond location. This information could reduce a driver’s fuel consumption and thus her emissions.

The Tekia system contains a small computer that monitors the driver’s speed and acceleration, immediately comparing these against an optimal model to encourage the driver to use the smallest possible amount of fuel, such as slower acceleration. The system is now being tested in Madrid.

“When we present this to bus operators, they’re very interested; they see that it can be translated directly into cost savings,” says Alejandro Sanchez, business development manager. The company estimates that the systems can pay for themselves in fuel savings in about three to four years.

Indra offers a system for making environmental measurements—of carbon dioxide and other city pollutants such as nitric oxide—in real time and sending that information to traffic managers “so that they can see if, for instance, the center of Madrid is overwhelmed with pollution, and they can make the decision to reroute traffic,” says Mario Hornero, manager of Indra traffic projects in Latin America.

These environmental advances, however, are incremental steps designed to fine-tune the current transportation system. Many companies are designing complete transformations of the way we move and power our vehicles.



Grupo Cegasa, in a partnership led by MIT, is taking part in rethinking urban transportation. That MIT team has designed a two-person stackable electric city car, designed to be picked up and dropped off at locations around a city. Cegasa has more than 25 years experience in developing batteries—it's one of the top battery manufacturers in Spain—and it is researching the battery and storage systems for these new vehicles. Cegasa is also partnering with a Spanish team, which includes the automobile manufacturer SEAT, to develop the next generation of lithium batteries for SEAT's coming electric car.

All major car manufacturers are now unrolling electric vehicle models, but the infrastructure does not yet exist to support those cars. Where will owners charge their cars? How will the charging stations operate?

Circontrol, located outside Barcelona, began designing charging-station solutions more than three years ago, when electric vehicles were still considered cars of the future. Company president Ramon Cornellas decided to invest research funds in developing charging stations. Admits Moisés Barea, Circontrol's export manager, "The first time I heard this, I thought it was a little crazy, because there were no electric vehicles yet." Because of Cornellas's foresight, however, Circontrol is now one of only three companies that is actually shipping charging stations to around the world to cities that are piloting electric vehicle programs.

Circontrol is part of the Circutor group, which works in the field of energy efficiency. In 2002, Circontrol designed its first parking-guidance system, a combination of ultrasound sen-

sors in each garage space, signal lights to alert drivers to the availability of a given parking spot, and LED signs to direct drivers through the garage. From the beginning, Circontrol's focus, leveraging its parent company's experience, was directed towards energy efficiency and savings. Circontrol quickly began to supply parking guidance to locations that include Turkey, Chile, and the Philadelphia airport.

As engineers focused on whole-garage energy systems, they realized that these locations will be prime spots for recharging electric vehicles, and began to turn research in that direction.

There are, however, a number of issues. First, there's as yet no standard for how cars will be charged, and whether they should operate off conventional plugs or use a larger charge, which would operate more quickly but demand different engineering. Engineers also found that if too many cars plug into the same source, they cause interference in the grid. They were able to solve these problems by creating a base model that can be modified depending on the types of car and plugs a manufacturer chooses.

But there are additional challenges that result from an entirely new mode of driving. How do you charge customers? "This is not just a socket—it's not something on the street where everyone can go and charge fuel for free," says Barea. So Circontrol created stations that must be activated, with either a credit card or a radio frequency identity tag that identifies the customer and can be charged to a linked account.

Security is also an issue. How do you prevent someone from unplugging a car, and then plugging in his own car on some-

one else's account? Circontrol built in a number of safeguards: in one, the charging station sends a small electrical charge out, which the car returns in a closed loop. If someone unplugs a car, that small charge drops, and so the larger charge turns off as well. They've also designed a metal "hat" that locks down over the plug after payment.

The company has already shipped more than 300 units to pilot programs across Europe. Electric cars, or plug-in hybrid electric vehicles, are now coming on line so quickly, says Barea, that "the challenge is to be ready with all our operations and logistics, with the stock ready to manufacture."

## IN SEARCH OF PARKING

Parking guidance systems have been gaining ground in parking garages around the world. The Parkare group provides guidance systems for more than fifty thousand parking spaces, along with license plate recognition hardware and software, and has sold more than twenty thousand of the on-street parking meters known as pay-and-display, which replace traditional meters with a fee boxes that sell tickets to be displayed in car windows.

Parkare is investigating the best ways to use the latest technologies to facilitate parking. "If you're booking a ticket on line for a movie, we can add another button to book your car space. So you can go to the movie and know that you have a spot reserved in the garage," says Francisco Martin, international division director of Parkare.

The most efficient system to charge drivers and manage traffic in a city challenged the owners of Barcelona-based Open Traffic Systems to develop an entirely new on-street parking method, which they refer to as a "complete parking solution."

The centerpiece of the design is a payment kiosk, which not only accepts payment for the parking space, but displays an entire computer screen to manage the interaction. The user types in her license plate number, pays for parking time, and gains access to information on bus routes and local businesses.

The license plate information is then sent to a central server, which broadcasts the data to the ticketing authorities monitoring the streets with handheld PDAs. Open Traffic Systems also provides a system for the authorities to use while driving around and checking the license plates: two cameras mounted on a car scan the streets and can read the plates, matching plate numbers against ones in the system. This technology was unveiled in a 500-unit system around the northern city of Bilbao, and is now being sold elsewhere in Europe and North America.

The technology demands a greater upfront investment than traditional parking meters, according to Clint Burnette, Open Traffic Systems project manager, "but you need fewer enforcement agents, and they take less time [to figure out who deserves a fine]."

In the latest upgrade, geared towards environmental sustainability, the system can run off solar power. It also includes Circontrol's electric car charging stations as a payment option, and offers rugged, gear-free bikes (to avoid damage common to city rental bicycles) that can be paid for at the kiosk and deposited at other sites around a given city. One such pilot system has been installed in the north of Barcelona.

Even at a time of economic challenges, cities envision these systems as potential revenue sources that will yield a good return on investment, adds Burnette: "We've hired new people for the last six months, and we have so much work we'll have to hire more."

## Resources

**ICEX (Spanish Institute for Foreign Trade)**  
[www.spainbusiness.com](http://www.spainbusiness.com)  
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**AMEC URBIS**  
[www.amec.es](http://www.amec.es)

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[www.munimadrid.es](http://www.munimadrid.es)

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**INDRA**  
[www.indra.es](http://www.indra.es)

**MINISTERIO DE FOMENTO**  
[www.fomento.es](http://www.fomento.es)

**OPEN TRAFFIC**  
[www.opentraffic.net](http://www.opentraffic.net)

**PARKARE**  
[www.parkaregroup.com](http://www.parkaregroup.com)

**PARKHELP**  
[www.parkhelp.com](http://www.parkhelp.com)

**QUERCUS TECHNOLOGIES**  
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**TECSIDEL**  
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