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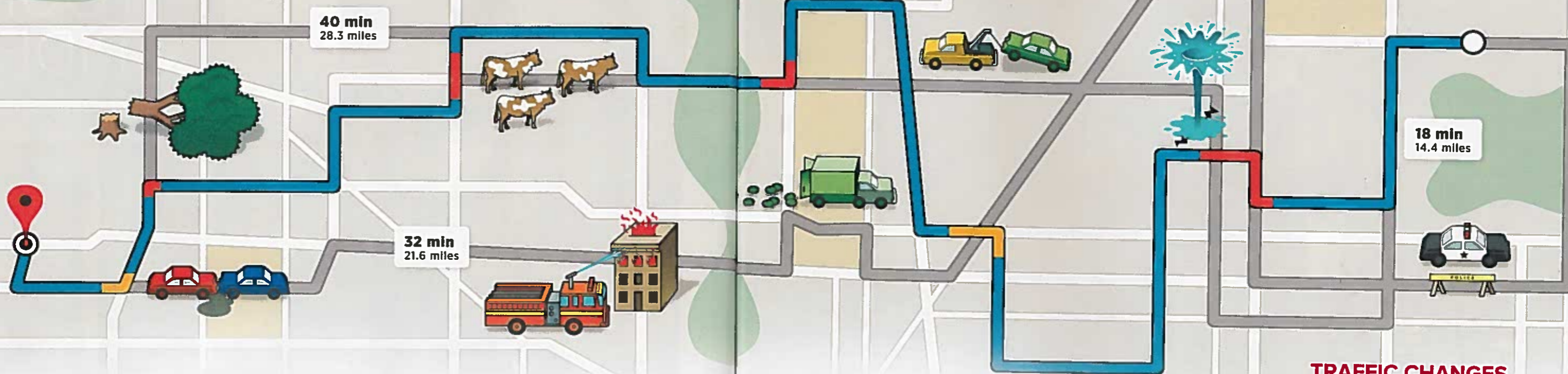
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# WHERE Do You Want to Go Today?

How navigation systems figure out the route to your destination, and how they will become central to the cars of the future. BY WAYNE CUNNINGHAM

Six years ago while driving an Audi A6 in San Francisco, the car's navigation system directed me to get on the freeway to travel just six city blocks. I ignored the instructions, sticking to surface roads.

Then last November, while driving back to San Francisco from Los Angeles, I hit the Bay Area during the afternoon rush hour on a Friday. When I fired up Google Maps on my phone, it directed me to a bridge crossing I wouldn't normally take, while constantly assuring me it was the fastest route. This time, I followed directions and got home an hour earlier than if I had blindly taken my accustomed route.

I wasn't just trying my luck that second time. Between these two events, navigation routing had improved substantially, letting me trust it more. For me, navigation systems have completely replaced paper maps.

But how do navigation systems plan those routes? Are we really better off letting them take the wheel? As it turns out, yes.

## It all starts with the map

To understand how navigation route planning works, I talked to engineers from some of the biggest companies in the industry.

At the core of any navigation system is a digital map. And for major navigation companies such as Google, Here and TomTom, building them is a complex process. Engineers start with detailed maps showing every road and highway in a specific region correlated to GPS coordinates. To give their maps better detail, they analyze satellite imagery, plumb municipal planning information and send out probe cars with high-precision GPS receivers and cameras to drive over miles of roadway.

The results can be infinitely precise down to the direction of one-way streets and even whether a two-way street has a center divider.

Mapmakers also give each street a priority code, or a numerical rating, for how quickly cars should be able to travel on them. Aaron Dannenbring, senior vice president at Here, says the company's maps categorize roads in five classes. The fastest roads, such as freeways, get a 1 rating, while one-way alleys and 25 mph suburban streets more likely to slow your roll get a 5. When rating a road, Here also applies a list of over 750 attributes, from school zones and left-turn restrictions to designated animal crossings and even areas with high crosswinds.

Likewise, Google compiles its maps using a mix of satellite data, information from local governments and probe cars. The company then assigns priority codes based on factors such as the number of lanes on a road and, as Amanda Leicht Moore, Google Maps product manager, told me, how quickly the company's probe

cars can drive on it. All of that data helps Google better match its road data with real-world driving.

## Deciding where to go

Once it has a digital map full of priority codes for every road, a navigation system can plot your route between two places. When you tell your system where you want to go, its algorithm runs through the map like a supersonic rat in a maze. It seeks the quickest roads, those with the best priority codes, and tries to minimize your time on the slowest roads.

Navigation experts refer to routing as a "cost calculation," the system's algorithm looking for the route with the lowest "cost" in miles and time. Or as Chad Maglaque, senior director of product management for Inrix, puts it, "Most navigation engines try to get you to freeways as fast as possible."

Navigation systems from 10 or even just five years ago, relied only on which roads should be the fastest, often suggesting routes that baffled local drivers—hence my first experience in San Francisco. But refinements to the underlying maps, such as Here's road attributes that include information affecting speed of travel, have substantially improved route planning. Google's Moore says that one goal of her team is to make Google Maps navigation "mimic local knowledge," so that its routes look like those a driver with intimate knowledge of an area would use to avoid traffic or other complications.

## Beyond directions

Within the next 10 years, navigation will mean more than simple turn-by-turn directions to get you around. Mike Tzamaloukas, vice president for automotive equipment supplier Harman International, says "navigation systems will become more of a supportive function for a number of different subsystems in cars," and provide context for what's going on around you.

Rather than merely telling you to turn right or left at intersections, future navigation systems might tell the steering and headlights about an upcoming turn, as one example. In fact, Rolls-Royce has already implemented a transmission in its Wraith model that relies on navigation to know when it is approaching a hill, downshifting ahead of time to ensure the passengers enjoy the gentlest ride.

And even further ahead, navigation will play a central role in self-driving cars, telling the car how to get you home while letting you chat with family or watch TV. When that day comes, the car will not only make decisions about avoiding traffic, pedestrians and objects, it will implicitly trust the route given to it by the navigation system, taking you out of the equation entirely. ●

Wayne Cunningham (@way4ne), managing editor for CNET's Roadshow site, has been covering the convergence of cars and technology for over 10 years.

## TRAFFIC CHANGES EVERYTHING

While an accurate digital map is the foundation for navigation, it doesn't account for how other drivers navigate the roads. Traffic, long a plague of drivers everywhere, can slow a normally fast road to a crawl, throwing a wrench into your nav system's careful planning. But thanks to the data connections from our phones and even our cars, navigation systems can stay one step ahead.

Using Telenav's Scout app to guide me to a destination in Los Angeles recently, I marveled as it directed me away from the freeways with angry red hues on the map (indicating 0 to 20 mph speeds) to relatively quiet surface streets. Even with stoplights, I cruised along relatively unhampered by other drivers. It was wonderful. But as I drove I thought about how the app's behavior went against its core programming, which would be to seek out the freeways it was now avoiding.

Perhaps unwittingly, you're telling mapping companies about traffic jams. Consider the more than 1 billion monthly active users of Google Maps. Amanda Leicht Moore, Google Maps product manager, says that some, particularly those using Google's Waze app, are very engaged, reporting incidents they encounter on the roads.

And unless you've turned off Location Data Collection on your Google Maps app, you passively contribute to Google's traffic information. As you travel, your speed and location are uploaded and anonymously aggregated with all other users, then feed the traffic and incident information you see on the app. Google and other companies also gather traffic data from public transportation authorities, which offer it up for the general good, and private fleets, such as FedEx trucks.