Science of Figuring Out 'Mystery' Traffic Jams
Explanations abound for problem

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It's one of the great conundrums of commuting -- you're sailing along a freeway at 50 miles per hour, when suddenly the brake lights go on in front of you and in seconds you're down to stop-and-go. Creep, crawl. Creep, crawl.

After a while, the traffic jam loosens, and you are back up to 40 or 50.

But there is no apparent reason for this slowdown -- no wreck blocking a lane, no stall on the bridge. The radio says there was an accident somewhere ahead of you nearly two hours ago, but it has long since been cleared up. So why are you still crawling along, thinking it would be faster to get out and walk?

Well, drivers are not the only ones who wonder about this. In fact, there are hundreds of people who get paid to study traffic jams -- some from the cockpits of radio traffic planes and helicopters, some from government agencies and others from university offices and transportation institutes.

One place to try to figure it out is in a Cessna 172, flying over the Bay Area traffic jams for a few hours.

``It's the mystery traffic jam,'' says Dave Callahan, an airborne traffic reporter for KGO and a man who has spent the past 10 years watching the ebb and flow, the yin and yang of the Bay Area's daily traffic snarls from his lofty perch. ``You'll have a three-mile jam and at the front end, where the accident was, all of a sudden the lane clears and traffic starts moving.

``There's an incremental Slinky effect,'' he says, referring to the springlike toy that bounces down stairs, seemingly on its own willpower. ``The traffic begins to pick up close to the point of the accident, but at the back of the line, they're still stopped.''

In the world of traffic engineering, they sometimes call this the ``shock wave'' or ``backward-forming wave'' of traffic jams. Civil engineers who specialize in parsing traffic
say the simple explanation is that when one tiny glitch happens at the head of a long line of cars, it throws everything off because there is a momentary time lag as each driver hits the brakes. As the cars slow down, they bunch up, creating a thick density of bumper-to-bumper vehicles.

The shock waves, according to Alex Skabardonis, a research engineer at the University of California at Berkeley, are changes in the density of traffic. You have a certain number of cars in a certain space (on a road). If the density gets too high, a driver's freedom to maneuver gets less. You see the flow getting slower, then everything is at a standstill and it resembles a parking lot."

Skabardonis likes to use that example of a driver traveling along at 50 when a car ahead has to stop for a red traffic signal, or a dog in the road, or something. The brakes start going on, car by car, back down the line, and if you were watching from, say, a toll booth, you would see the rear lights blinking on in a backward march down the line of cars, like bright red dominoes falling against each other.

``The wave propagates back,'' Skabardonis says, ``because each driver has a reaction time that takes a few seconds. So the wave keeps going backwards, and then, when the traffic signal way up ahead turns green, you have another wave -- the recovery wave."

The problem is compounded because the recovery wave takes longer than the slowing-down wave.

``You go very quickly from slow to stop-and-go,'' says Hani Mahmassani, professor of civil engineering and director of the Advanced Institute or Transportation Infrastructure Engineering and Management at the University of Texas at Austin, ``but going quickly from stop-and-go to slow does not happen.

At the California Department of Transportation, the engineers who deal with these matters on a daily, hands-on basis tend to agree with the ivory tower guys, but they put the problem on a more down-to-earth level.

``The major cause of congestion is too many cars and not enough road,'' says Albert Yee, chief of highway operations for Caltrans' District 4, which is responsible for keeping traffic moving on some 500 miles of freeway in the nine-county Bay Area. ``Too many cars trying to squeeze into too few lanes."

Yee says the mystery traffic jam really is not much of a mystery at all. It comes down to bottlenecks.

``When we teach new traffic people about this, we talk about the (highway as an) hourglass,'' he says. ``The narrow point in the hourglass is the bottleneck. And the Bay Bridge is the classic bottleneck. You have three major freeways -- 880, 580 and 80 -- coming together to five lanes."

So the classic Bay Bridge traffic jam happens when, for instance, a westbound car breaks
down in the far-left lane halfway up the incline, on the upper deck, at 7:15 a.m.

Caltrans says the bridge is designed for a capacity crowd of 10,000 cars per hour. So if one of those five lanes goes down because of a stall, you've lost 20 percent of your capacity and everything starts falling apart.

``You lose a lane, and it creates a bottleneck,'' says Sean Nozzari, the District 4 operations manager. ``The amount of time it takes the last car in line to clear that bottleneck depends on how fast you can clear the bottleneck.'' And it usually is not easy.

All kinds of things cause delays, particularly when drivers slow down to check out the latest mangled metal a few feet away.

``This is the spectator input,'' says Nozzari. ``We call it the gawking effect. The smaller the incident, the less the gawking effect. The bigger the incident, the more of it there is. They slow down more for an ambulance than for a tow truck. It's the human nature of it.''

So, what can the experts do about this? Not enough, say some critics, who charge that dealing with mystery jams is not the highest priority in American highway and transportation departments.

``Generally, the U.S. is less aggressive in trying to control this problem than, say, Germany, which uses more active technologies that sense the behavior of traffic,'' Mahmassani says.

``They use variable speed-limit signs to get them to slow down ahead of time, as well as electronic speed limit signs that are triggered by sensors sensing the speed of the vehicles. It works fairly well.''

Yet Caltrans is still trying to alleviate these rippling traffic jams, Nozzari says. To that end, Caltrans and the California Highway Patrol have a joint operation that monitors Bay Area freeways through 120 closed-circuit television cameras, 550 sensors embedded in the freeway pavement and cell-phone calls from drivers already stuck in the jams. Caltrans also uses changeable message signs that warn drivers of traffic jams ahead and offer them alternate routes.

Crucial to keeping traffic from bunching up are the metering lights, particularly the 16 lights about 1,000 feet west of the 19 toll booths at the Bay Bridge.

Normally, the lights are set to blink onto green about every three seconds, but if the bridge is backed up, Caltrans will slow it down to a range of from five to 10 seconds.

``The philosophy of metering lights'' Yee says, ``is to get as many cars across the bridge as possible. Capacity is 10,000 cars an hour and at the head of that line you already have 3,000 carpools and buses (that have gone through the commuter lanes). So the metering system has to restrict the rest of the flow to 7,000 cars an hour.''

But making traffic flow smoothly is still a fitful process that, Caltrans acknowledges, appears to be getting worse because of the profusion of cars clogging the roads.
To cope with the future, Caltrans is batting around ideas such as "congestion pricing"--charging higher tolls at peak periods--and, once there's a new Bay Bridge, adding breakdown shoulders on the left and right so that wrecks can be pushed out of the traffic stream.

For now, however, we can look forward to more of the same.

Asked for his perspective, from the cockpit of his traffic plane, zooming over the jellied thickness of thousands of cars, Callahan, the KGO reporter, said, "You take a backup that might be 40 car lengths, and you come back over it in 10 minutes and it's doubled. What's it look like? It looks like chaos."

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