Traffic science struggles to keep cars flowing on highways in D.C. and elsewhere

By Brian Palmer, Published: July 25

Traffic science is one of those disciplines that seems permanently poised on the verge of a breakthrough. Professional journals regularly publish promising research, and the press trumpets their importance. In 1999, The Post reported that scientists had gathered at Los Alamos National Laboratory in New Mexico to solve our national traffic problem — just as an earlier generation of physicists had done to build the atomic bomb. And yet driving on the Beltway is still about as enjoyable as cleaning out your ears with a lemon reamer.

Why can’t we get anywhere?

It turns out that traffic is a deceptively complicated problem. It could be said to resemble molecular physics, in fact, since it’s a system of individual particles interacting in complex ways. Except, with traffic, the particles have minds of their own.

There are two kinds of traffic flow. In uncongested, stable flows, cars can move at or near the speed limit, and individuals are able to move in and out of lanes or enter the highway smoothly. Then, there’s what traffic experts call the “unstable regime,” what laypeople refer to as stop-and-go traffic. What scientists have figured out over the past decade or so is when and why traffic shifts between the two.

“We see in our models that traffic becomes unstable when the number of cars [passing a specific spot] per lane per hour reaches between 2,000 and 2,500. At that nominal capacity level, traffic is very likely to become unstable,” says Hani Mahmassani, a traffic scientist at Northwestern University in Chicago.

It’s entirely possible for 2,000 cars traveling at ordinary highway speeds to cross a particular line in a single lane in an hour, as long as they’re all moving at the same speed and no one tries to move in or out. But that rarely happens. Far more often, after just a few minutes at that high flow rate, something upsets the process.

Consider a classic case. A slow-moving car shifts into the left lane to pass an even slower-moving car. The car immediately behind the lane-changer has to decelerate dramatically — not just to the speed of the car in front of him, but slow enough to create a safe driving distance between them. The next car back has to slow down even more, again to give itself a cushion. This slowdown ripples back through the lane and eventually spreads into the other lanes as nearby drivers notice the sea of brake lights and reflexively slow down. Traffic researchers refer to this as a shock wave, and it can travel back for miles.

Eventually, the slower car moves back into the right lane, and the traffic speed picks up. From the perspective of a car a mile behind the instigator, there was never any reason for the slowdown.

Unfortunately, while we’ve gotten really good at understanding why traffic jams happen, our tools to prevent them are pretty limited. Some experts are proponents of ramp metering. That’s when each on-ramp contains a traffic light to control the number of cars entering the highway.
“Two thousand cars per lane per hour is great, but it can’t be maintained. And when the breakdown occurs, flow rate immediately drops to around 1,200,” says Mahmassani. “The ramp meters are intended to keep the rate around 1,750 or 1,800, which is more stable.”

Some cities have implemented ramp metering, but they haven’t been aggressive enough to make much difference. Planners are concerned about backups on on-ramps spilling out into the city streets and creating gridlock.

Variable speed limits are another tactic. When cars are driving at a wide range of speeds, traffic is more likely to break down. So engineers have installed electronic speed limit signs on some highways. When high flow rates indicate a likelihood of breakdown, government traffic managers drop the speed limit by 10 or 15 mph to create “speed harmonization.” It’s a useful way to forestall stop-and-go traffic.

Traffic scientists point out that there are limits to these maneuvers. Ultimately, there are several obstacles to real progress.

First, we don’t hate spending time in our cars as much as we pretend to. How do I know? “Because building more roads doesn’t improve traffic flow,” says Chris Barrett, a Virginia Tech professor who constructs traffic modeling systems and was involved in the Los Alamos effort. “If you decrease the amount of time it takes to travel a certain distance to work, people just move farther away from their offices [for larger yards and cheaper housing, instead of staying put to reduce their commutes]. It changes behavior in a negative way.”

Moreover, people have strongly resisted the best congestion-fighting tool that can be immediately implemented. Every traffic expert I spoke with pointed out the runaway success of London’s congestion pricing system. Drivers who want to enter the heart of the city during busy times have to pay 10 pounds — about $16. The system has made a huge difference in reducing congestion, and the city is using the extra revenue to renovate the subway and add buses.

New York Mayor Michael Bloomberg tried to adopt a similar strategy in 2007, but the state government killed it. A congestion tax has never gotten anywhere in the D.C. area, which one recent survey found was first in the nation as measured by hours wasted stuck in traffic.

The other obstacle to progress is a general failure to apply technology in the transportation sector. Autonomous or semi-autonomous cars — vehicles equipped with computers that take over from drivers once they reach the highway — have the potential to ease traffic. They would be able to drive closer to one another, because computers have better reaction times than humans. They would also create better speed harmonization, since the vehicles could be programmed to drive in predictable ways.

Unfortunately, it’s going to be a long time before most of the cars on the road are driving themselves. The pitifully slow pace of technology adoption in the transportation industry is a problem, says Barrett.

Hybrid car technology is “most significant breakthrough in cars in decades,” Barrett notes. “But it’s not a conceptual breakthrough. It still has four wheels filled with air. It still has shocks and a combustion engine. We have a systemic lack of imagination in automotive transportation.”

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