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The Inconvenient Truth About Traffic Math: Progress Is Slow

By CARL BIALIK

This month's 60-mile traffic jam in China has demonstrated a frustrating truth about traffic: It is far easier to measure than mitigate.

Mathematicians, engineers and planners are making steady advances in assessing traffic congestion and explaining it. Radar and GPS devices help pinpoint cars and relay traffic data in real time. And sophisticated models can explain maddening phenomena such as phantom jams, when cars slow even without congestion. But traffic math's strides in reducing congestion are modest, simply because the number of cars often exceeds roadway capacity.

If population and the economy keep growing, "there is absolutely no way congestion can stop increasing," says Alex Bayen, an associate professor of systems engineering at the University of California, Berkeley.

And congestion hasn't stopped increasing. The Texas Transportation Institute, a research group at Texas A&M University, has tracked traffic in hundreds of U.S. urban areas since the 1980s. One measure, the Travel Time Index, indicates how much longer a trip takes during peak travel time—generally, rush hour—than when there is free flow. In 1982, a rush-hour trip took 9% longer, on average. A quarter century later, after steady increases, the peak trip took 25% longer than when the road was clear.

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A jammed section of the Beijing-Zhangjiakou highway in Huailai.

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David Schrank, co-author of the institute's Urban Mobility Study, says things would be even worse without creative, data-driven measures to manage traffic, such as ramp metering, which controls the flow of vehicles onto highways. But these tools don't make a huge difference: They shaved an average of about three minutes of travel time for each rush-hour commuter, each week.

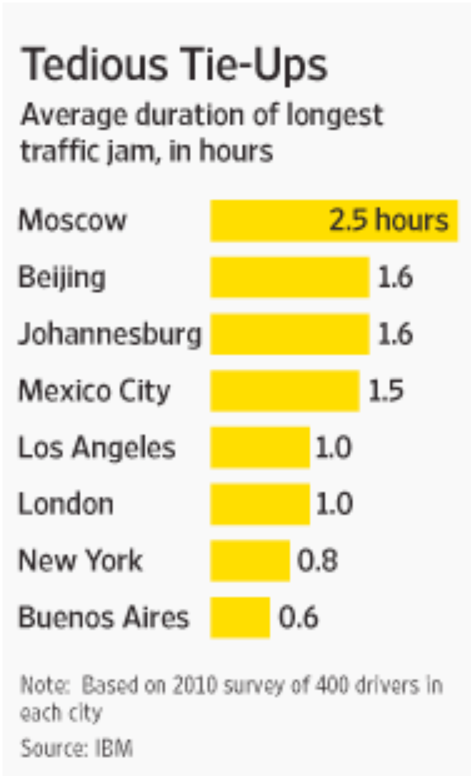
This still might be a better track record than the alternative approach of adding roads, which traffic engineers say often have only a fleeting impact on easing congestion. Instead, new roads lead to more travel, because of an effect that Martin Wachs, director of RAND Corp.'s transportation, space, and technology program, describes as triple convergence. Many drivers who had shifted their trips to off-peak hours, or to different roads, or to public transit, resume their previous pattern and converge onto the new highway.

Rather than plan new roads, most traffic engineers are working to spread traffic out more evenly. The first step is to measure demand more accurately. In the 1930s, traffic engineers stood on the side of the road, clipboard and stopwatch in hand. Today, they have tools such as radar, lidar, detectors embedded in roads, and video, says Robert Bertini, deputy administrator of the Department of Transportation's Research and Innovative Technology Administration.

Prof. Bayen's research group is merging such data with inputs from cars' GPS devices. The idea is to stitch together all these data points—60 million per day—to detect patterns and build a prediction engine. "The game now is massive data fusion," says Prof. Bayen. "We're trying to bring mathematical answers to these questions." His next goal is to predict traffic accurately within 20 minutes, at 80% reliability.

IBM is designing systems that cities can use to weave together information about multiple modes of transportation, including road and rail, then attempt to shift traffic accordingly. The company expects to sign a contract in the next month with a U.S. city, says Naveen Lamba, the company's global lead for intelligent transportation, that will use such information to tell drivers, via electronic roadway signs, how long it will take to get to a popular destination by different routes. "We can get a lot more use out of our existing transportation infrastructure," says Mr. Lamba.

Efforts to improve traffic flow run up against immovable obstacles. For one thing, special incidents make up a consistently large proportion of traffic delays: between 53% and 54% every year since 1982, according to the Texas Transportation Institute. Such delays are, by their very nature, unpredictable: a truck accident, say, or a massive blizzard. That limits the potential impact of traffic engineering.



Also, mathematical models tend to assume rational behavior by drivers, which isn't always a given. For instance, Nicholas Taylor, a research fellow at the consulting company Transport Research Laboratory in Wokingham, England, says that adding road capacity can be effective if it isn't perceived as adding capacity. Opening a highway's shoulder to traffic during peak hours appears to work, Mr. Taylor says, because it is "not seen as a whole new provision of the road. There's a psychological element to it."

In addition, traffic can slow even without heavy demand, because of driver reaction time. Traffic engineers have shown that even when the number of vehicles shouldn't tax a road, a small perturbation—such as a slight deceleration by one car—can ripple through the cars behind them, as they brake in reaction. Japanese researchers in 2008 published a study demonstrating the effect experimentally in 2008, by assigning roughly two dozen drivers to cruise along a closed circular track at about 19 miles per hour. After some time, a jam developed, and the cars within it ground to a halt until the cars ahead of them accelerated. The jam traveled backward through the track at roughly 12 miles per hour.

Gabor Orosz, a mechanical engineer at the University of Michigan, and his colleagues have demonstrated why this occurs mathematically, developing a model that accounts for driver reaction time. "Driver behavior is very important," says Dr. Orosz. "It would be great to have a magic formula. What we are thinking is that there is no magic formula."

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