Bicycle route selection

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BY HARRISON SCHRAMM

I ride my road bike about 120 miles week in a good week. In the Monterey, Calif., area, I have a number of good options for cycling, but which routes are safest? Being on the bike gives one time to think. I've thought about this quite a bit and can put some analysis into it – about five minutes worth (just shy of two miles at 20 mph).

While cycling solo, there are two reasons that you may crash. The first and most dangerous is an accident (which I call Type I) in which you hit or are hit by a car. The second (or Type II) is that you "spontaneously" crash – by hitting something unseen in the road, such as a stick or a squirrel, or due to sudden catastrophic mechanical failure, like a flat tire. The simplest way to avoid being hit by cars is to avoid roads with traffic; however, these are not automatically the safest roads, because if you have a Type II crash, you may be waiting for a long time for help to arrive.

The "best" situation, it would seem, is to be where you are never passed by a car, but if you crash, one will instantly be there, like a team car following 100 yards behind you at all times. Amateur athletes don't have this luxury; we have to rely on the notion that the driver of a car witnessing a bicycle crash of either type will call for help.

Our objective now is to create a simple yet non-trivial model to gain insights about this problem. Let ρ be the average spacing between cars, S_c be the average speed of traffic and S_b be the bicycle speed. We'll assume that a bicycle will never overtake a moving car. We'll also assume that the distances between cars are random and uncorrelated – a good assumption on remote rural roads, a horrible assumption in the city.

To get at the math, let's think this way: First, we take a strip of paper and mark the positions of the individual cars, which as a result of our assumptions above will be Poisson with parameter ρ. Now, we move this strip past a stationary point at a speed of $Max(0, S_c - S_b)$. The distribution of car-bicycle interactions, N, for a bicycle ride of distance D is Poisson with a parameter $\lambda = \frac{\rho(S_c - S_b)D}{S_b}$ if $S_c > S_b$ and zero otherwise.

Notice how S_b appears twice; first subtracting off the speed of the cars and also as a denominator. In English, this means that the faster you go, the lower your interaction rate with cars is, as well as the less time you spend on the road. It doesn't take much calculation to see that this number is minimized if $S_c \leq S_b$, or, in English, if you ride at a speed comparable with traffic.

To understand the waiting time after a Type II crash, we set $S_b = 0$. Because we've assumed that the distribution of car locations is Poisson, we may deduce that the distribution of waiting times is exponential, with a rate parameter $\lambda = \rho S_C$.

For example, if the speed of traffic is 25 mph, a cyclist rides 10 miles at 15 mph, and the average traffic density is one car every two miles, then the distribution of the number of cars that will interact with the bicycle during the ride is shown in Figure 1. The distribution of waiting times post-crash is shown in Figure 2.

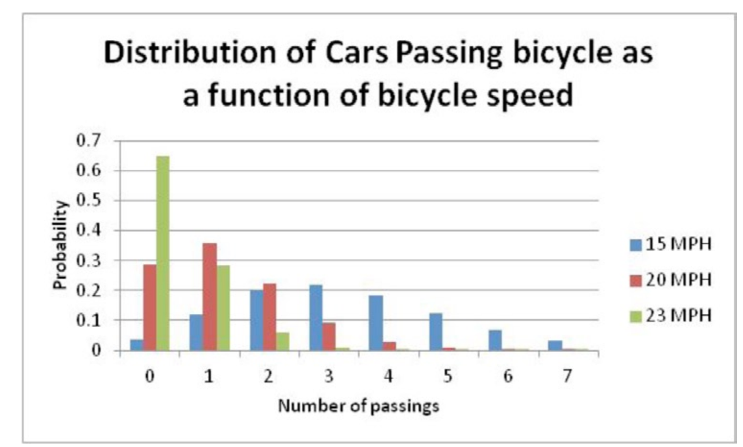

Figure 1: Distribution of bicycle-car interactions; as bicycle speed increases, the distribution of car passages shifts to the left. At 23 mph, there is a 65 percent chance that the cyclist will be passed by no cars during the entire ride.

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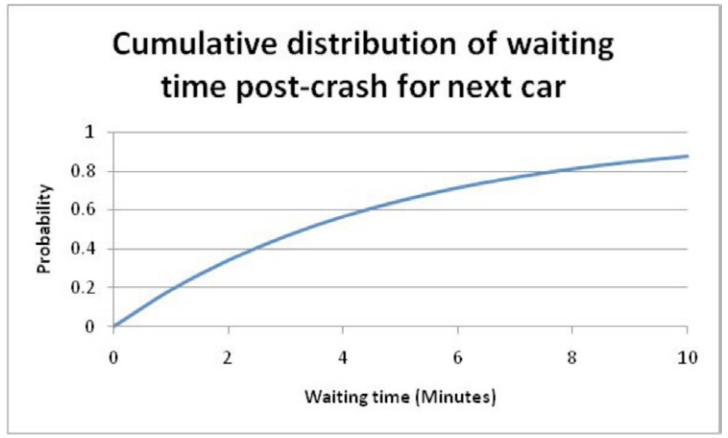

Figure 2: Distribution of waiting times post-crash in our example. This is a function of traffic density and speed only and is the same for all rider speeds.

So it would seem that our mathematics confirms what we already suspect: the safest thing for a cyclist to do is to select roads where he or she rides at a rate that is similar to the prevailing speed of traffic. This is something that is already well known in the cycling community but is worth reinforcing. This also explains why the 17 Mile Drive in Pebble Beach is my favorite route!

Bonus: Not all drivers are the same. If you have a feel for the population of dangerous drivers, call it p_d , then the occurrence of interactions with dangerous drivers will be the same as before, substituting $\rho_d = p_d \rho$.

***Harrison Schramm** (harrison.schramm@gmail.com), INFORMS member, is a military instructor in the Operations Research Department at the Naval Postgraduate School in Monterey, Calif.*