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FROM PARKING LOT TO PARADISE

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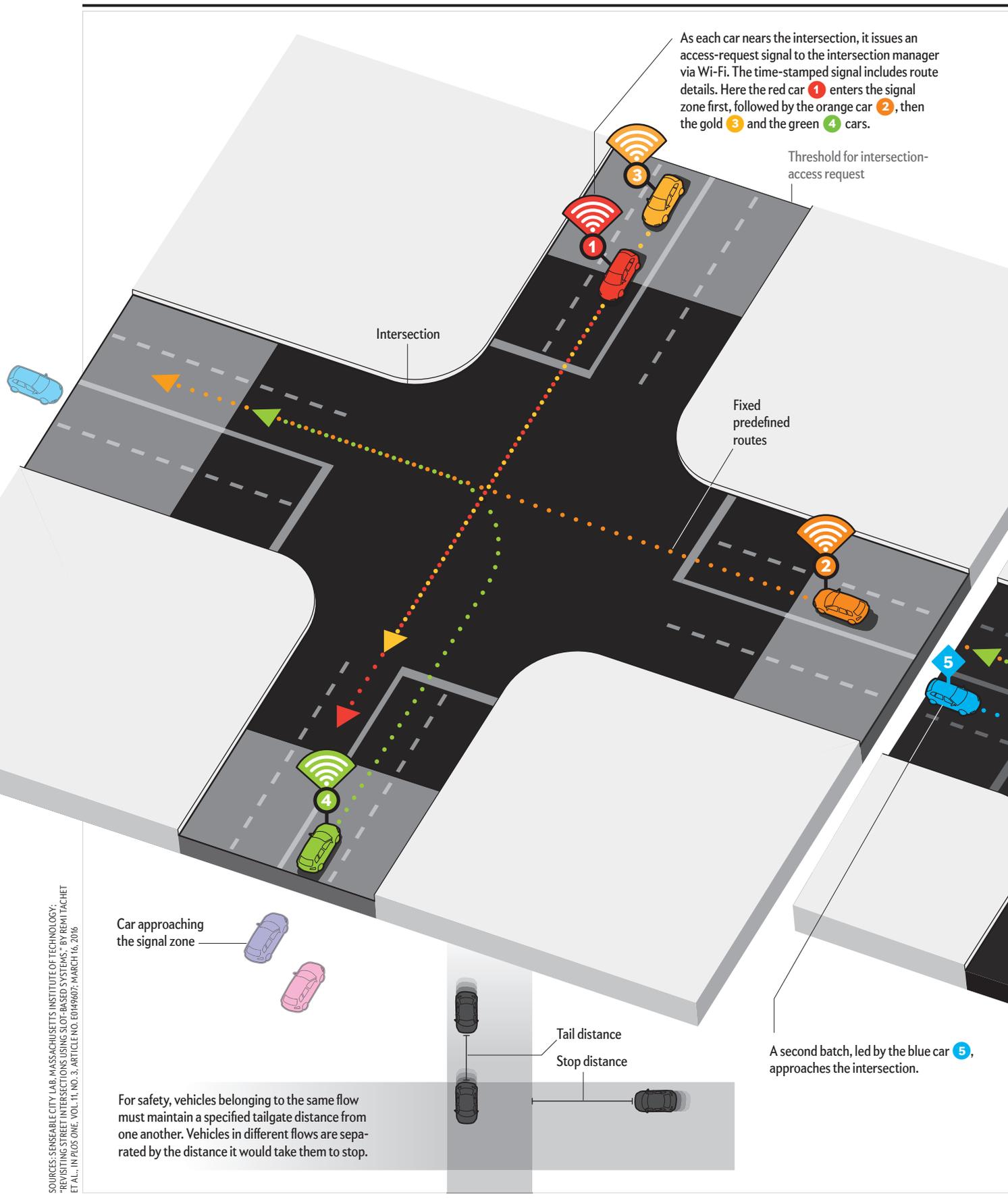


A moving web of sensor-laden vehicles and smart intersections will transform how we get around town

By Carlo Ratti and Assaf Biderman

CARS AND CITIES HAVE A COMPLICATED relationship. Today, plagued with swelling road congestion and rising air pollution, we tend to think of the two as increasingly incompatible. But during the 20th century the automobile left one of the most durable marks on city planning. As Swiss-born architect Le Corbusier declared in his seminal 1925 book *The City of To-morrow and Its Planning*, “The motor-car ... has completely overturned all our old ideas of town planning.”

Almost 100 years later we are at a similar turning point. First, demand for urban transportation is expected to more than double by 2050, which means that we will need to more than double capacity on the roads just to keep congestion at the (often unacceptable) levels we experience now. Second, thanks to the rapid convergence of information and communication technologies, robotics and artificial intelligence, our mobility systems—cars, buses and other forms of transportation—are undergoing massive transformations. Once again,



As each car nears the intersection, it issues an access-request signal to the intersection manager via Wi-Fi. The time-stamped signal includes route details. Here the red car **1** enters the signal zone first, followed by the orange car **2**, then the gold **3** and the green **4** cars.

Threshold for intersection-access request

Intersection

Fixed predefined routes

Car approaching the signal zone

Tail distance
Stop distance

A second batch, led by the blue car **5**, approaches the intersection.

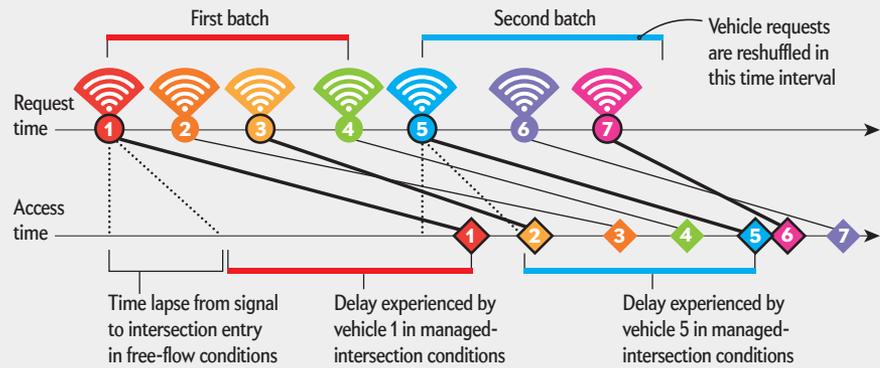
For safety, vehicles belonging to the same flow must maintain a specified tailgate distance from one another. Vehicles in different flows are separated by the distance it would take them to stop.

SOURCES: SENSEABLE CITY LAB, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; "REVISITING STREET INTERSECTIONS USING SLOT-BASED SYSTEMS," BY REMI TACHET ET AL., IN PLUS ONE, VOL. 11, NO. 3, ARTICLE NO. E0499607, MARCH 16, 2016

Traffic Control

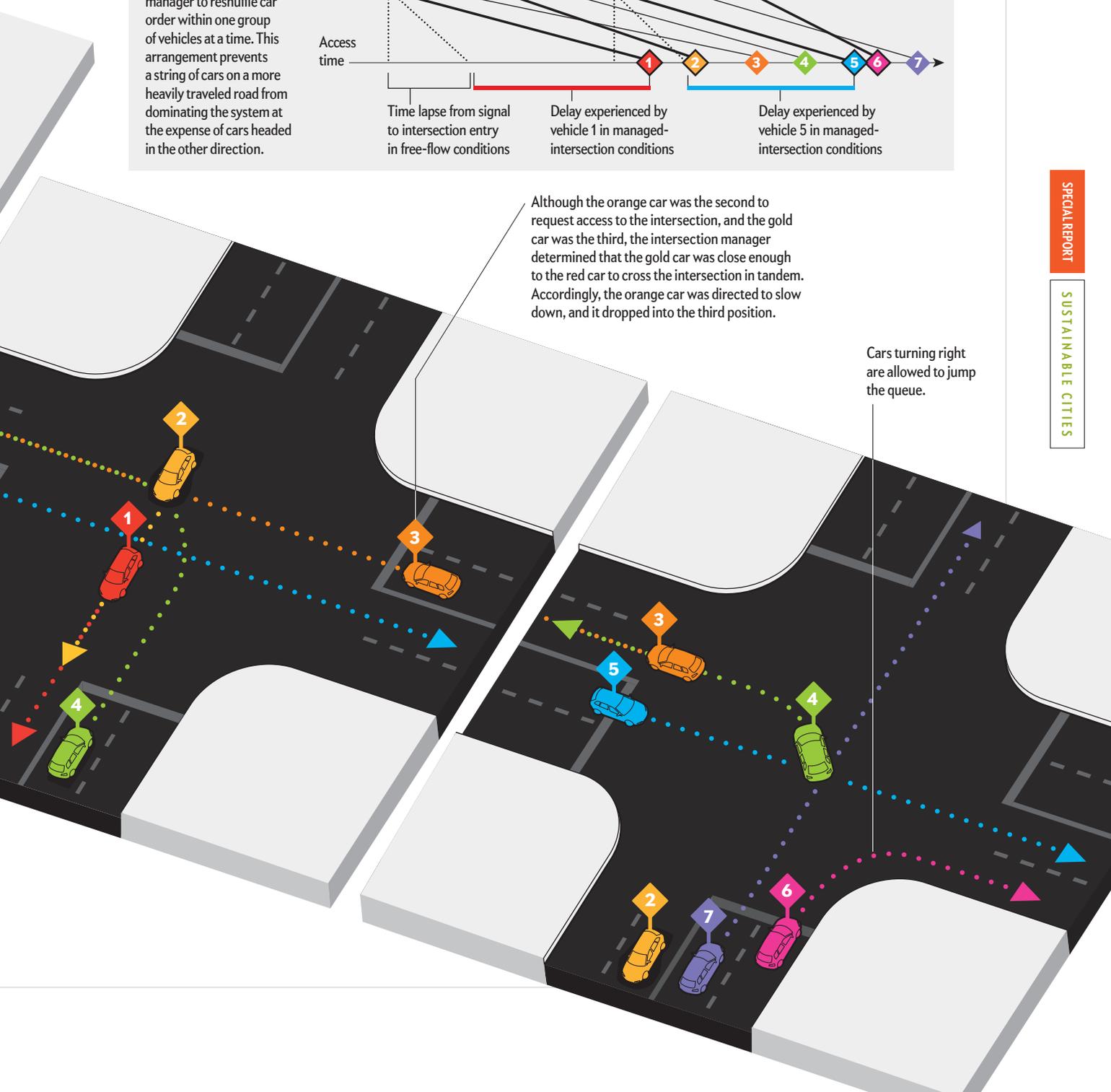
Self-driving vehicles would enable city planners to replace traffic lights with slot intersections, in which each vehicle approaching an intersection is assigned a time “slot” when it can pass through. Research suggests that slot intersections could allow twice as many vehicles to pass through an intersection in a given amount of time, compared with traffic lights.

Slot intersections are most efficient when vehicles are grouped together in batches, allowing the automated-intersection manager to reshuffle car order within one group of vehicles at a time. This arrangement prevents a string of cars on a more heavily traveled road from dominating the system at the expense of cars headed in the other direction.



Although the orange car was the second to request access to the intersection, and the gold car was the third, the intersection manager determined that the gold car was close enough to the red car to cross the intersection in tandem. Accordingly, the orange car was directed to slow down, and it dropped into the third position.

Cars turning right are allowed to jump the queue.



they stand poised to radically reshape the urban landscape.

Self-driving (or autonomous) vehicles are leading the charge. In recent decades cars have shifted from the kinds of mechanical systems Henry Ford might have recognized to veritable computers on wheels. The average car is now equipped with an array of sensors that collect internal and external data to help it run safely and efficiently. Companies such as Waymo (spun out of Google), Cruise (acquired by General Motors), Otto (acquired by Uber), Zoox and nuTonomy, for example, are experimenting with additional sensors that can “see” a street much in the way our eyes do. Once you feed that information into an onboard artificial-intelligence system, you get a fully autonomous vehicle, capable of navigating on busy traffic grids without any human input.

Autonomous cars will free up much of the time we spend every day driving, and they will make our roads safer. They are going to be game changers for our cities—but in ways that are far from decided. On one hand, we can imagine that more people will begin to share these vehicles so that the machines can give lifts to one passenger after the other, all day long. In that case, our cities might run using a small fraction of the vehicles currently in service. On the other hand, we might have more dystopian scenarios. Robin Chase, co-founder and former CEO of the car-sharing service Zipcar, has written of “zombie cars—those with no one in them—clogging our cities and our roads.” Her vision foresees unemployment for professional drivers, lost revenue from our transportation infrastructure, and “a nightmare of pollution, congestion, and social unrest.”

Technological nirvana or urban dystopia? To tackle this question, we need to delve into the ways autonomous vehicles could alter our cityscapes and the ways we move through them.

THE SHARING ECONOMY

ON AVERAGE, cars sit idle 96 percent of the time. That makes them ideal candidates for the sharing economy. The potential to reduce congestion is enormous. A handful of car-sharing systems—such as Zipcar and car2go—are already having a major impact on the total number of vehicles in our cities.

Scholars have estimated that every shared vehicle removes nine to 13 privately owned cars from the streets.

The benefits will grow exponentially as autonomous vehicles, currently available in experimental forms, gain a notable portion of the market, blurring the distinction between private and public modes of transportation. “Your” car could give you a lift to work in the morning and then, rather than sitting in a parking lot, give a lift to someone else in your family—or to anyone else in your neighborhood or social media community.

As a result, a single vehicle could go from one to 24 hours of use a day. A recent paper by our colleagues at the Massachusetts Institute of Technology reports that, under such conditions, the mobility demand of a city like Singapore—host to one of the world’s first publicly accessible fleets of self-driving cars—could be met with only 30 percent of its existing vehicles. In addition to vehicle sharing, auton-

omy could open up a new wave of ride sharing. Already applications such as Via, uberPOOL and Lyft Line allow different people to share the same ride, cutting operating costs and individual fares. Autonomy could boost ride sharing even more because all trips could be managed online. In cities, the potential for ride sharing is significant, based on analyses by our Senseable City Lab at M.I.T.

New York City, for example, is eminently shareable. Our lab’s HubCab project gathered data from 170 million taxi trips involving 13,500 Medallion taxis in the city—specifically, the GPS coordinates for all pickup and drop-off points and corresponding times between the two. We then developed a mathematical model to determine the potential effect of ride sharing applied to those journeys. The project introduced the concept of “shareability networks,” making it possible to optimize the trip-sharing opportunities. Our quantitative results revealed how taxi sharing could reduce the aggregate number of cars by 40 percent with only minimal delays for passengers. Further work showed that places such as San

Francisco, Vienna and Singapore could benefit in similar measure.

Combine car sharing *and* ride sharing, and a city might get by with just 20 percent the number of cars now in use, with its residents traveling on-demand. Of course, such reductions are theoretical. In real life, they would depend on how willing people are to share rides and adopt self-driving technology. But any drop in the number of vehicles could lower the costs and energy associated with building and maintaining our mobility infrastructure. Fewer cars might also mean shorter travel times, less congestion and a smaller environmental impact.

NO PARKING, NO TRAFFIC LIGHTS

AUTONOMOUS CARS will not require additional urban infrastructure—specially designed roads, for example—but they will lead to other significant changes. Consider parking. In the U.S., parking infrastructure covers around 8,000 square miles, an area

Vast areas of urban land could be redeveloped to support social functions.

nearly as large as New Jersey. If more vehicles were shared, we would need dramatically fewer parking spaces. What would the consequences be?

Over time, vast areas of valuable urban land, currently occupied by parking lots, could be redeveloped to support a whole new spectrum of social functions. Park(ing) Day, an annual event first held in San Francisco in 2005, offers some preliminary ideas. Every year the event challenges artists, designers and citizens to transform metered parking spots into temporary public places. In the past, participants have rolled out sod and placed trees and benches along the curbside.

On a much larger scale and on a permanent basis, vacant parking lots could be converted to offer shared public amenities such as playgrounds, cafés, fitness trails and bike lanes.

Other common sights along our city streets might vanish. Take traffic lights, a 150-year-old technology originally conceived to help horse carriages avoid collisions. Sensor-laden self-driving vehicles, which can communicate with one another to maintain safe distances, will need

less assistance at road crossings. As a result, slot-based intersections, modeled after air traffic control systems, could replace traffic lights. On approaching an intersection, a vehicle would automatically contact a traffic-management system to request access. It would then be assigned an individualized time, or “slot,” to pass through the intersection.

Slot-based intersections could significantly reduce queues and delays, as our Light Traffic project has demonstrated. Analyses show that systems assigning slots in real time could allow twice as many vehicles to cross an intersection in the same amount of time as traffic lights usually do. This arrangement could have a major impact on the road network of any given city. Travel and waiting times would drop; fuel consumption would go down; and less stop-and-go traffic would mean less air pollution. As an added bonus, slot-based intersections are flexible enough to accommodate pedestrians and bicycles sharing the road.

It is worth noting that such an enticing vision depends on more than just autonomous cars and smart traffic-management systems. It also requires much better market coordination. Today’s car-sharing companies have independent platforms that do not talk to one another. Customers cannot compare options easily, and drivers cannot benefit from aggregated demand. The situation is similar to how the air travel industry looked before the Internet. Passengers can now compare many flight alternatives through several global distribution systems that follow standards established by the OpenTravel Alliance and thus benefit from increased transparency and competition.

In cities, two approaches could create a similar mobility architecture. The first would be a bottom-up effort in which small players start adopting standards. This is beginning to happen with a collaboration among Lyft, Didi Chuxing in China, Ola in India and GrabTaxi in Southeast Asia. The second effort would be top down, led by a government or a global organization, such as the World Wide Web Consortium. Because transportation services are already heavily regulated in most countries, this would not be too far-fetched. Either approach could create an incredibly powerful and transparent platform for transportation and logistical services.

POTENTIAL PITFALLS

VEHICLE AUTONOMY and ride sharing could create overwhelmingly positive changes in urban transportation. But if the transition to the driverless city is not managed carefully, it could also lead to negative consequences.

The first concern is safety. We all know what it is like for a virus to crash a computer. What if a virus crashes a car? Malicious hacking is difficult to combat with traditional government and industry tools, and it is particularly dangerous in the case of systems, such as self-driving cars, that combine the digital and the physical.

Additional problems might arise from what one could call the “unfair competitive advantage” of vehicle autonomy. The cost of traveling a mile might drop so substantially that people would abandon public transportation in favor of autonomous cars. That, in turn, could lead to an *increase* in the number of vehicles in a city—and with that increase, surreal gridlock. Additionally, keeping cars moving at all hours rather than parked 96 percent of the time could increase pollution.

Autonomous cars might generate another unintended consequence: aggravating urban sprawl. This would not be the first time that a technological innovation in mobility resulted in such an effect. In his 1941 book *The Four Routes*, Le Corbusier described how this unfolded in the first decades of the 20th century: “The railway converted the cities into true magnets; they filled and swelled without control, and the countryside was progressively abandoned. It was a disaster. Luckily the automobile, through the organization of the roads, will reestablish this broken harmony and start the repopulation of the coun-

tryside.” In the future, what if people, newly able to commute while sleeping or working, decide to relocate out of the city, consuming land and expanding unsustainable, sprawling communities?

A couple of other threats are worth mentioning. Fines, parking fees and car-associated taxes such as driver registrations represent a substantial revenue source for all kinds of local and national jurisdictions. Widespread autonomous vehicles could eliminate this crucial flow of money. We can easily imagine what would happen to already battered American infrastructure if this scenario were to come true. Perhaps cities could compensate by redeveloping unneeded parking lots and building new, revenue-producing infrastructure. But we must also remember that millions of drivers working today in logistics or urban transport jobs could be left unemployed worldwide.

As Robin Chase wrote, “Simply eliminating the drivers from cars, and keeping everything else about our system the same, will be a disaster.” As a result, it is imperative that we view these new technologies with a critical eye—and guide them toward the societal goals we desire. Good policy could help prevent the negative outcomes we have described. As was the case in the 20th century, much will depend on a healthy cycle of trial and error.

Still, if we can manage the transition in a thoughtful way, self-driving cars could help us achieve a safer and more pleasant urban experience. In doing so, they could ultimately enhance the very mission of our cities, which dates to the emergence of the first human settlements 10,000 years ago—bringing us together, regardless of the kind of vehicles we are moving in. ■

MORE TO EXPLORE

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For details about Park 20|20: www.park2020.com/en

Massachusetts Institute of Technology’s Senseable City Lab: <http://senseable.mit.edu>

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The Efficient City. Mark Fischetti; September 2011.

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