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CONTENTS

ACCESS Magazine reports on research at the University of California Transportation Center. The goal is to translate academic research into readable prose that is useful for policymakers and practitioners. Articles in ACCESS are intended to catapult academic research into debates about public policy, and convert knowledge into action.

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The University of California Transportation Center, founded in 1988, facilitates research, education, and public service on the University of California campuses at Berkeley, Davis, Irvine, Los Angeles, Riverside, and Santa Barbara, and on the California State University campuses at Pomona, Sacramento, San Bernardino, and San Luis Obispo. Authors of papers reporting on research here are solely responsible for their content. Most of their research was sponsored by the US Department of Transportation and the California Department of Transportation, neither of which is liable for its content or use.

Shedding Weight

You probably have an extra pen in your car, or a discount card for a coffee shop you'll never go to again. Maybe you have a Swiss army knife, or two, just in case it's the end of the world and one isn't enough. We constantly add extra weight to our travels just in case we might need something. The booming self-storage industry shows just how hard it is for us to let things go. But when you consider that Americans drive almost three trillion miles every year, all that extra weight adds up to a huge waste of energy.

These added ounces also weigh upon an increasingly polluted environment, with every gallon of gas we use generating 20 pounds of CO_2 emissions. But what if our cars went on a diet? Imagine how much gas we could save and pollution we could prevent if drivers took five minutes to clean out a pound of weight from their vehicles. Or better yet, what if drivers worked off a pound from their own waistline by walking or biking, and leaving the car at home?

Just as drivers tend to carry too much in their cars, writers tend to add too much weight to their writing, adding an extra clause here, an extra adjective there, just to make sure their meaning is clear. In the end, it slows down the work and pollutes the narrative. That's why *ACCESS* is unique. Our authors and editors spend extensive time trimming the fat so that readers aren't slowed down by what Elmore Leonard calls "the parts people tend to skip." And our efforts are paying off.

We are proud to announce that *ACCESS* has won American Planning Association's National Planning Excellence Award for a Communications Initiative. In 1993, UC Berkeley planning professor Mel Webber founded *ACCESS* to bridge the gap between transportation research and policy. After 21 years, we continue to translate academic research into reader-friendly prose. In this issue, we present six well-trimmed articles.

Michael Manville examines how removing minimum parking requirements facilitated the redevelopment of historic and architecturally significant buildings in downtown Los Angeles.

Two articles focus on Carmageddon and Carmageddon II, the traffic closures that occurred on one of the busiest highways in the nation. Brian Taylor and Martin Wachs look at how the closures affected travel behavior. Arthur Winer, Yifang Zhu, and Suzanne Paulson find dramatically lower pollution levels during the closures.

Karen Trapenberg Frick argues that pursuing the sublime can transform infrastructure improvements into excessively lengthy and expensive megaprojects.

Joseph Schofer and Raymond Chan emphasize the importance of creating a culture of experimentation in transportation.

And Donald Shoup suggests that there's a better way to spread charity during the holiday season than giving away free parking.

Thanks to all of our funders, authors, editors, and readers who made the National Planning Excellence Award possible. And special thanks to those who wrote letters of support, whom we list below. We hope you all enjoy this issue. (Please don't leave it in your car.)

John A. Mathews
Managing Editor

THANK YOU:
Jonathan P. Bell, LA County Department of Regional Planning
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PARKING REQUIREMENTS AND HOUSING DEVELOPMENT

REGULATION AND REFORM IN LOS ANGELES

MICHAEL MANVILLE

When cities require off-street parking with all new residential construction, they shift what should be a cost of driving—the cost of parking a car—into the cost of housing. A price drivers should pay at the end of their trips becomes a cost developers must bear at the start of their projects. Faced with these minimum parking requirements, developers may build less housing, and the housing they do build may be more likely to include parking. Parking requirements could therefore reduce both the amount and variety of housing in a city.

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Will parking requirements always have this impact? No. In low-density areas where parking is cheap and most people want it, developers might build lots of parking even if it isn't required. In downtowns and inner cities, however, parking requirements could profoundly alter the housing stock. Downtown land is expensive, its parcels are often small and irregular, and its buildings frequently cover their entire lots. In these situations, any on-site parking must be subterranean or structured, which is always expensive and sometimes physically impossible.

When parking is difficult to provide, laws that require it on-site with housing are laws that constrain the housing market. Minimum parking requirements can make it difficult to build housing for certain people, on certain parcels, in certain buildings, or in certain neighborhoods. When cities require on-site parking with every unit, developers cannot build housing explicitly for people without cars (who are often low-income), or for people who own cars but are willing to park off-site. The law also makes it difficult to construct housing on small parcels. Nor can developers easily convert old buildings into housing. Central cities have many architecturally and historically significant buildings that predate widespread vehicle ownership and thus lack parking or the space to add it. These old buildings should be a competitive advantage for cities; they are a pleasing amenity most suburbs lack. If parking requirements keep these buildings vacant, however, they ➢

A price drivers should pay at the end of their trips becomes a cost developers must bear at the start of their projects.

become albatrosses rather than assets. And if old buildings and small parcels dominate a neighborhood, as they do in many inner cities, then parking requirements can stifle an entire neighborhood's growth. Parking requirements could, in sum, obstruct infill development, affordable development, and neighborhood redevelopment.

The logic above suggests that if cities remove parking requirements, they will encourage more and more varied housing. In 1999, the City of Los Angeles put this idea to the test by enacting an Adaptive Reuse Ordinance (ARO) for its downtown. The ARO was designed to convert vacant commercial buildings into housing. The law had three components. First, it allowed these buildings to use an alternative fire and earthquake code. Second, it allowed developers to change the buildings' use (from commercial or industrial to residential) without variances, thereby avoiding lengthy appeals and delays. Last and most important, the law exempted the buildings from minimum parking requirements. Although developers couldn't remove any existing parking, they also didn't have to add any. If developers chose to provide parking, it didn't have to be on-site or reserved for residents. And unlike developers of conventional buildings, ARO developers could lease spaces to commuters, businesses, or visitors.

The ARO thus provided an opportunity to answer two questions. First, would removing parking requirements help convert these empty buildings, many of them vacant for decades, into housing? Second, and perhaps more interesting, were downtown's parking requirements influencing the *type* of housing produced there? Because new ground-up housing was still subject to parking requirements, the ARO turned downtown into a laboratory for parking regulation. The law created a set of downtown buildings that faced the same market conditions as other properties—the same amenities, crime levels, and transit access—but that did *not* have minimum parking requirements. The ARO therefore lets us compare what unregulated developers *did* with what they *would have had to do* if they were regulated. The law also permitted a comparison between unregulated developers and those facing parking regulations. Did the unregulated developers provide less parking than zoning would have called for, and less parking than their regulated counterparts? If so, how did this affect the quantity and type of type of housing built?

To answer these questions, I surveyed 56 ARO developments and gathered information about how they provided parking. I also examined over 1,500 downtown housing units using real estate transaction records, and interviewed planners, developers, and architects involved in converting ARO buildings into housing. What I found suggests that when cities remove parking requirements, developers build more housing with less parking, often in buildings and neighborhoods they had long ignored.

Housing, Historic Buildings, and the Adaptive Reuse Ordinance

The exact number of downtown housing units the ARO created is hard to determine, partly because the city doesn't keep precise records, and partly because LA's downtown boundaries aren't clearly defined. Almost everyone agrees, however, that the law generated a lot of housing. By my own conservative count, between 1999 and 2008 developers used the ARO to create about 6,900 units in downtown LA. Between 2000 and 2010, downtown LA added a total of 9,200 housing units, so the ARO accounted for over 75 percent of that decade's housing construction. Between 1970 and 2000, downtown LA added 4,300 housing units; the ARO created more housing in less than ten years than had been created in the previous thirty [Figure 1].

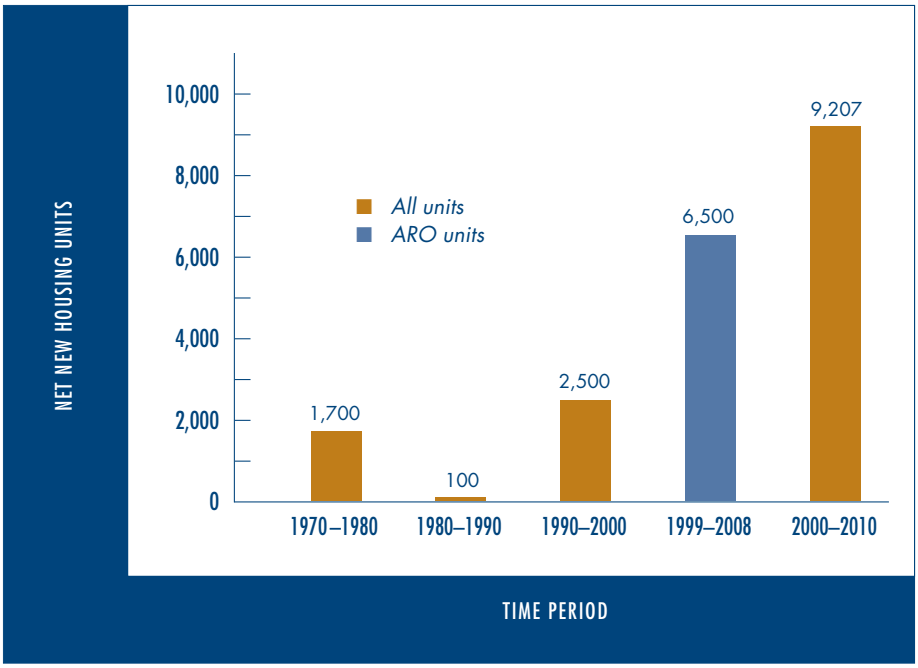


FIGURE 1

Housing Growth in Downtown Los Angeles

The ARO buildings were disproportionately old—their median year of construction was 1922—and many were near each other. Thousands of ARO housing units are clustered in a single census tract. Once known as the "Wall Street of the West," this neighborhood was home to Bank of America's headquarters, the Los Angeles Stock Exchange, and other financial institutions. The area has the nation's largest collection of intact office buildings constructed between 1900 and 1930, many of them exemplars of West Coast Beaux Arts and Art Deco architecture, and is listed on the National Register of Historic Places. In the 1960s, however, this elegant district began to decline, and in 1982 the *Los Angeles Times* described it as "a neighborhood of hoodlums, derelicts and winos … echoing buildings full of absolutely nothing above the ground floor." In 1980, the census tract had just over 3,100 housing units and 1,700 residents. Subsequent housing growth was tepid; by 2000, the tract had just over 3,600 housing units. From 2000 to 2010, however, the area came to life. Both the housing stock and population more than doubled, and ARO buildings accounted for most of the increase. A dozen large ARO conversions alone created over 2,200 housing units.

Housing booms are easier to document than explain. What caused the downtown turnaround? Was the ARO's parking deregulation specifically responsible for all this development? My interviews suggest that parking reform was a necessary but not sufficient condition for the ARO's—and neighborhood's—success. Simply removing parking requirements would not have let developers convert these buildings to housing, because the buildings didn't conform with many aspects of the zoning code. At the same time, however, most respondents said that without removing the parking requirements, the conversions would have been impossible.

If parking requirements prevented adaptive reuse, we should see ARO developers provide less parking than conventional zoning would mandate. Apartment developers must provide one covered, on-site parking space for each rental unit of up to three ➢

"habitable rooms" (kitchen, common area, or bedroom). In larger buildings with larger units, the city requires 1.25 covered, on-site spaces per unit.

Condo parking requirements are at the discretion of a special planning advisory agency, which until 2005 usually required 2.25 to 2.5 covered, on-site spaces per unit. After 2005, however, the agency began requiring fewer spaces, often two spaces per unit and sometimes as few as 1.5.

Figure 2 compares these requirements to the amount of parking ARO developers actually provided. I conservatively assume that, without deregulation, the city would have required one space per unit for all ARO apartments, and two spaces per unit for condos.

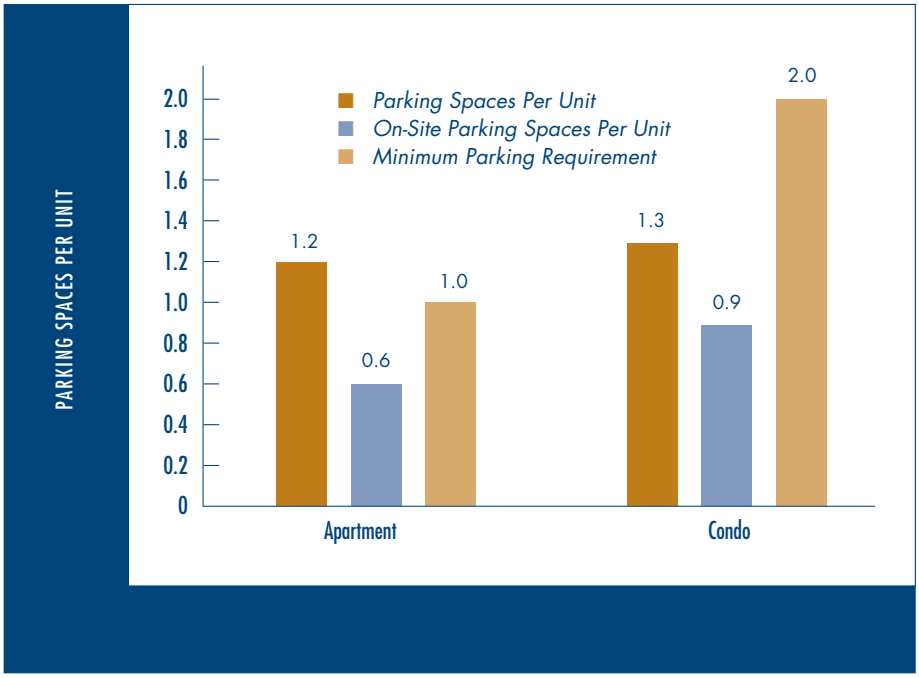
Deregulated apartment developers actually provided more parking than zoning would have required. The downtown requirement calls for one space per unit, and ARO developers provided an average of 1.2 spaces. But these averages don't tell the whole story, for four reasons.

First, the baseline is conservative; many apartments would actually have required 1.25 spaces each, and many condos 2.5 spaces apiece. Second, the averages mask substantial variation. Some upscale apartment buildings provided two spaces per unit, while others provided less than one, and one building provided none at all. With parking requirements, any variation below the minimum would have been illegal. Third, some of these buildings had large amounts of pre-existing parking (one building sat atop a parking structure), and these spaces bias the count upward. Fourth and most important, the average ignores the parking's *location*. Stricter parking requirements will have a bigger influence on housing development, and stringency is determined not just by how many spaces the city requires, but *where* the city requires them. LA requires all parking on-site.

Requiring parking on-site can make construction costs rise rapidly. On a tight parcel the first four surface spaces might cost $4,000 apiece, but a fifth space could require

FIGURE 2

Parking Spaces Provided in ARO Housing



building structured parking or digging a garage. That last space could cost tens of thousands of dollars—far more than any value it adds to a housing unit. Letting developers provide some or all parking off-site lets them control the cost of that next space. Rather than dig costly garage spaces, developers can rent existing spaces nearby.

ARO developers took full advantage of the law's locational flexibility. ARO apartment buildings provided an average of 1.2 spaces per unit, but only half of those spaces were on-site. The rest were usually leased from nearby parking structures or lots. Had ARO buildings been subject to the downtown parking requirement, all spaces would have had to be on-site.

With ARO condos, the disparity between zoning requirements and developer behavior is even larger. The 19 condo buildings in the sample account for just under 2,100 housing units, and on average, each condo unit has 1.3 parking spaces, much less than zoning would require. Yet as was the case with rental units, the difference is magnified when we take the parking's location into account. ARO condos provided less than 1 space per unit on-site.

Sixteen of the 56 ARO buildings provided all their parking off-site, while an additional nine buildings offered tenants some combination of on- and off-site parking. Twelve more buildings provided at least some parking in an uncovered surface lot, which would also be illegal under LA's parking requirements. ➢

Residents without cars are forced to pay for parking they don't want.

More Diverse and Less Expensive Housing

Since most housing includes parking, new housing without parking diversifies the housing stock. And because this new housing lacks parking, it might also be less expensive. According to the Census Bureau's American Housing Survey, 90 percent of LA's housing units include a parking space in their rent or purchase price. In contrast, over one third of the ARO buildings did not include parking in the price of their units. This probably isn't a coincidence. Developers often bundle parking with housing because parking requirements force them to oversupply spaces, at costs well above what those spaces could sell for on their own. Developers thus have little choice but to bundle the parking's cost into the housing price. In addition, LA requires developers to reserve parking spaces for residents. This rule, which virtually guarantees bundled parking, helps no one. Developers can't sell extra spaces to non-residents who want to buy them, and residents without cars are forced to pay for parking they don't want.

Freed from these rules, ARO developers unbundled their parking. I analyzed statistics for 1,559 downtown lofts for sale or rent in downtown LA. These units were in 45 different buildings, 29 of which were converted to housing using the ARO. ARO apartments were three times more likely to be offered without parking as non-ARO apartments (13 percent to 4 percent), and ARO condos twice as likely (31 percent to 14 percent). My results also suggest that units without parking are less expensive than units with parking. Controlling for many other differences, bundled parking was associated with about $200 a month in additional rent for apartments, and over $40,000 in additional selling prices for condos. Unregulated developers supplied a different, less expensive product than regulated developers.

No Parking Requirement ≠ No Parking

Residents often worry that without parking requirements, developers won't build parking at all, leading new residents to park on and congest the street. The ARO shows that such fears needn't come to pass. Many housing buyers and lenders want parking, so most developers provide it. The ARO's parking exemption was valuable not because it let developers forgo parking completely, but because it let them supply parking creatively. If developers thought they could sell some units without parking or with parking off-site, they were free to try. And they were not forced to construct individual spaces that were wildly expensive (e.g., spaces that forced them to dig a second garage level).

Minimum parking requirements address a real problem (the demand for off-street parking), but also tell developers how to solve that problem (provide a set number of covered spaces on-site with every unit). Removing parking requirements doesn't remove the problem (buyers might still want parking), but it does remove the one-size-fits-all solution. Developers can provide parking in the way *they* think is best, the same way they already provide pools, fitness centers and other amenities.

This suggests some important lessons. First, removing a parking requirement is not the same as prohibiting parking; ending a mandate is not the same as enacting a ban. Second, because developers remain free to provide parking, cities can remove parking requirements even if most people drive. The end of parking requirements doesn't assume the end of driving. Plenty of people drive in downtown LA (it's *Los Angeles,* after all). And when most people drive, most developers supply parking.

But what if some developers *do* construct buildings without parking, and residents *do* bring cars? That situation arose in Portland, Oregon in early 2013, and caused both street parking congestion and a zoning controversy. Yet nothing of the sort occurred in Los Angeles, for a simple reason: LA regulates its downtown streets. There is no destructive competition for free street parking in downtown LA because there *is no free street parking.* Downtown streets are metered from 8 am to 8 pm, and on most streets overnight parking is prohibited. This is perhaps the most important lesson of the ARO: deregulated off-street parking needs regulated on-street parking. When cities don't give on-street spaces away for free, developers will provide—and drivers will pay for—spaces off-street.

Conclusion

Minimum parking requirements force a marriage between housing and vehicle ownership, and make it hard to build housing for people without cars. Because parking can consume so much space and money, parking requirements needlessly reduce variety in the type and location of housing available: they render some parcels, buildings and neighborhoods unprofitable for residential development. This result is unfortunate. Housing consumers, like consumers in all markets, have myriad tastes. Of course many people want parking attached to their unit. But "many people" is not "everyone." Some people will live in buildings with little parking. Maybe these people don't drive, or don't mind parking a small distance from where they live. Perhaps they could not afford housing if it automatically included a parking space. Parking requirements deprive these people of options, and threaten the vitality of cities. Cities thrive when they offer more rather than fewer choices; cities that remove parking requirements will create more diverse and inclusive housing markets, and become more diverse and inclusive places. ◆

This article is adapted from "Parking Requirements and Housing Development: Regulation and Reform in Los Angeles," originally published in the *Journal of the American Planning Association.*

Further Reading

Michael Manville. 2013. "Parking Requirements and Housing Development," *Journal of the American Planning Association*, 79(1): 49–66.

Michael Manville, Alex Beata, and Donald Shoup. 2013. "Turning Housing into Driving," *Housing Policy Debate*, 23(2): 350–375.

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Carmageddon in Los Angeles: The Sizzle and the Fizzle

BRIAN D. TAYLOR AND MARTIN WACHS

"Carmageddon" refers to the horrific traffic jams predicted when a bridge reconstruction project in Los Angeles required closing 10 miles of the Interstate 405 freeway on two weekends. The closed freeway through the Sepulveda Pass between West Los Angeles and the San Fernando Valley is one of the most heavily traveled arteries in the world, with more than half a million vehicles passing through on a typical summer weekend. Traffic from the closures was predicted to back up for miles and spill onto local streets, severely congesting some parts of Los Angeles.

Public officials tried to avert the expected traffic jams by warning drivers to stay away. Some of their messages appealed to civic pride and encouraged responsible voluntary cooperation. Others threatened nightmarish gridlock throughout the region. Media coverage was especially intense for the first closure, often gleefully focusing on a likely traffic disaster.

We studied how the roughly 300,000 travelers who traverse the affected stretch of the San Diego Freeway per typical summer weekend day responded to the two closures. To do so, we compared traffic volume and transit ridership from each of the closure weekends to baseline control dates before and after each event.

How did the public respond to the freeway closures and to the warnings of traffic chaos? Rather than creating chaos, the first closure greatly *reduced* traffic congestion. Most people chose to cancel trips rather than to reschedule them, but the reductions in travel diminished over the course of the weekend closure as people learned that congestion levels were far below the dire forecasts.

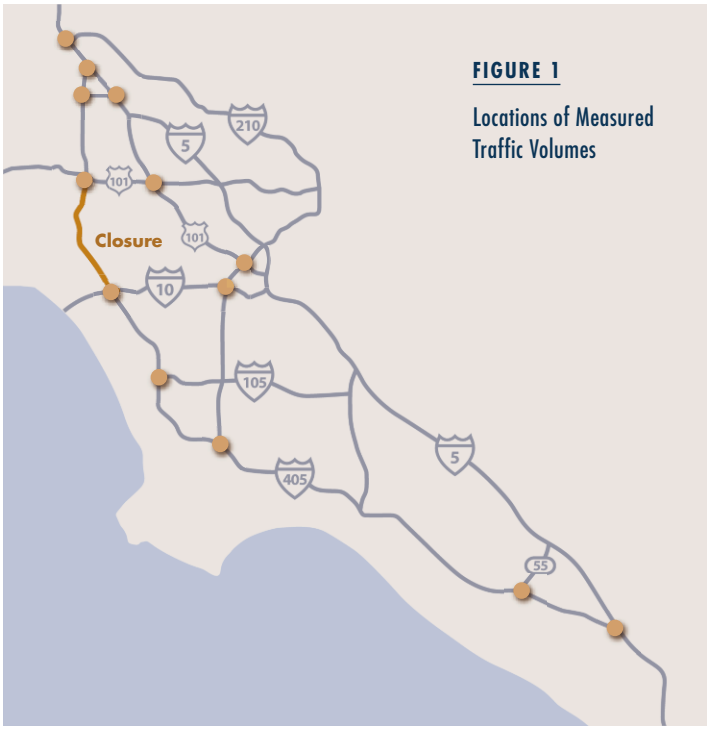

FIGURE 1

Locations of Measured Traffic Volumes

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The Freeway Closures and Plans to Address Them

During the first freeway closure, contractors demolished the southern half of the Mulholland Drive Bridge over the 405 freeway. Reconstruction was followed by the second weekend closure a little over a year later for the demolition and subsequent reconstruction of the northern half of the bridge.

The Los Angeles County Metropolitan Transportation Authority (Metro), California Department of Transportation (Caltrans), and City of Los Angeles began planning well in advance to mitigate the effects of the closures. Plans included temporarily adding transit service and an aggressive outreach campaign, asking people to stay away, far away, from the closure. During the 2011 closure, Metrolink, the regional commuter rail authority, expanded commuter rail service and promoted a $10 weekend pass that allowed unlimited rides and free transfers to any bus or rail service in the region. Metro operated higher levels of service and free fares on its Red, Purple, and Orange Lines. It also increased service on closure-adjacent bus routes including one running parallel to the closure.

To expand street capacity, the Los Angeles City Department of Transportation (LADOT) extended no-parking zones along major arterials near each closure. The California Highway Patrol used aircraft to monitor roadways so that crews could respond quickly to stalls and accidents. Caltrans established a state-of-the-art command center near downtown Los Angeles to monitor regional traffic conditions and to direct traffic management teams toward hotspots.

Officials delivered print, radio, online ads, and email blasts to over 6,000 organizations. They configured electronic billboards to broadcast messages alerting highway drivers to the impending closure weeks in advance of the event. Metro used traditional websites, created Facebook pages for the events, and broadcast messages on Twitter, even leveraging celebrity star power for the first event, including Ashton Kutcher and Kim Kardashian. ➢


Sunday
Los Angeles Times
latimes.com
'It's like we live in a small town today…I wish it were like this all the time.'
'If the word "Carmageddon" did anything, it reduced this challenge to one word that everyone understood.'
'It can be perfectly safe and perfectly annoying at the same time.'
L.A. downshifts and takes it easy
Motorists largely heed the warnings about 'Carmageddon' and stay off the freeways.
Bridge demolition proceeding briskly
BEHOLD. Monica Angwed, wearing a T-shirt she made, gets into the spirit of the weekend in the public viewing area of the 9th street Skirball Center Drive.

Communications and the Media

Public agency managers and elected officials delivered both optimistic and pessimistic messages. Caltrans' Los Angeles District Director was upbeat when he advised, "You're going to be surprised by what you discover in your neighborhood if you take that opportunity." Likewise, Metro's Executive Director of Highway Programs said, "It's really going to take all of us Angelenos working together by staying home and shopping locally to keep our region moving."

Concerned with the repercussions of public failure to heed upbeat calls for behavior change, several elected officials delivered more ominous messages, particularly prior to the first event. Los Angeles County Supervisor Zev Yaroslavsky coined the term "Carmageddon" to alert the public to the potential impact of the closure: "This doesn't need to be a car-mageddon; the best alternative route is to totally avoid the 405 area, completely avoid it, don't come anywhere near it, don't even think about coming to it. Stay the heck out of here." Los Angeles Mayor Antonio Villaraigosa said, "There's gridlock on the 405 virtually any time of the day…and if you think it's bad now, let me just make something absolutely clear: on July 16th and 17th, it will be an absolute nightmare." City Councilman Paul Koretz chimed in that motorists should "avoid the area like the plague."

In the weeks leading up to the first closure, the media picked up and repeated news of the closure, often emphasizing the dramatic aspect of the story: monumental traffic jams were likely if motorists failed to heed officials' warnings to avoid the area. Saturation coverage ensured that warnings of Carmageddon and its potential effects had reached nearly every driving age adult in Southern California by the time of the first closure.

While two distinct messages—one of hope and one of fear—went out, the messages of fear captured the media's imagination. The dominant image that emerged from the chorus of local and national news reports and the huge volume of blogs, tweets, and Facebook messages was not a promise of adventure and opportunity, but of doom. News headlines leading up to the event reported on how to "brace" for Carmageddon, "escape" from Carmageddon, how technology would "protect" Los Angeles from Carmageddon, how to "avoid" Carmageddon, and how to "arm" Angelenos against Carmageddon.

While transportation agencies broadcast messages similar in tone and scale for Carmageddon II the next year, the second event garnered more modest and measured media coverage locally, and almost none nationally or internationally. Taken together, the two closures provide valuable data on changes in short-term travel behavior in response to major planned traffic disruptions.

Both closures began on Friday at 7 pm. Caltrans closed on-ramps, then connectors, and then shut down each lane. By midnight 10 miles of the I-405 in the northbound direction from the I-10 to the US-101, and 4 miles in the southbound direction from the US-101 to Getty Center Drive were closed to traffic.

Data Sources and Methods of Comparison

We obtained freeway traffic data from Caltrans, traffic volumes on arterial streets from the LADOT, and transit ridership data from Metro and Metrolink. We compared travel during the weekend closures against a baseline calculated as the average of four mid-summer, non-holiday weekend days in 2011, and four early-fall, non-holiday weekend days in 2012. This allowed estimation of what traffic volumes would likely have been had Carmageddon not occurred.

FIGURE 2

Carmageddon Bus Routes Analyzed

Although the first closure was scheduled to run from Friday evening through early Monday morning, the work proceeded more quickly than expected, and the actual closure ended mid-day Sunday morning, about 15 hours early. The second closure ended an hour earlier than scheduled, early on Monday morning.

Travelers' Responses to the Closures

Despite widespread media reports of impending disaster, traffic during the first freeway closure fell far below expectations, and even far below normal, on nearby freeways, adjacent surface streets, and even far-flung parts of the freeway network. Carmageddon II results were much more mixed; freeway volumes were down significantly from the baseline near the closure, but were up in some areas farther away. Adjacent surface street volumes relative to the baseline also rose significantly unlike the first closure.

To determine the extent to which travelers detoured around the closure, we examined freeway traffic flows on the most likely alternative routes as well as on adjacent surface streets north and south of the closures. In virtually all cases during Carmageddon I, traffic levels were down, often substantially, along potential detours near and far. During Carmageddon II, freeway volumes were mostly down near the closure, but the effects diminished with increasing distance from the closure. Overall we found: ➢

How did the public respond to the freeway closures and to the warnings of traffic chaos? Rather than creating chaos, the first closure greatly reduced traffic congestion.

No evidence of preemptive or postponed trips: There were no substantial shifts in trip-making to weekends before or after the closures, or to days before or after the closures.

No evidence of mode shifts: Travelers did not shift to public transit during either closure. In fact, they shifted *away* from transit use during Carmageddon I, despite increased service. Metro Route 761 parallels the closed segment of the I-405, and when compared to the baseline ridership fell by more than 20 percent during both Carmageddons, even though Metro substantially *increased* transit service during the first closure.

Lower freeway traffic volumes near the closures: Travelers avoided driving near both closures. Traffic volumes on I-405 north and south of the closure were down by more than half during both Carmageddon I and II. On two intersecting freeways north (US-101) and south (I-10) of the closures, traffic was also down substantially.

Lower surface street traffic during first closure and higher during the second: People stayed off closure-adjacent streets during the first closure, but shifted from freeways to nearby streets during the second. During Carmageddon I, nearby surface street volumes rose on a few arterials near the freeway closure exits, but fell on many others, suggesting that drivers did not shift in large numbers from freeways to surface streets. In contrast, during Carmageddon II, nearby surface street volumes rose substantially and consistently, suggesting that at least some of the observed drop in freeway traffic shifted onto arterial streets.

Carmageddons affected traffic levels far from the closure: For Carmageddon I, there were statistically significant declines in traffic volumes across Southern California freeways, suggesting either that few drivers chose to detour around the closure, or that those who did were outnumbered by those who chose not to travel at all. For Carmageddon II, traffic rose slightly on several possible detours around the closure.

People quickly learned and responded: As the two weekend closures progressed, travelers responded to initially low levels of congestion by driving more.

Changes in travel behavior eroded over time and across events: Northbound traffic fell on routes leading to and away from the closure on the Saturdays of both Carmageddon I and II. The statistically significant reductions in traffic declined with distance, extending more than 50 miles from the first closure. On Sunday of the second closure, we observed virtually no deviations from the baseline, regardless of distance from the closure. This is remarkable because the Sepulveda Pass remained closed until early Monday morning. The breathtaking drops in traffic volumes observed on the Saturday of the first Carmageddon had eroded so much by the Saturday of the second Carmageddon that traffic volumes had returned to normal on the freeway that was still partially *closed*.

Lessons from the Twin Closures

The preparations for and responses to two similar closures of a major transportation artery provide an opportunity to analyze both travel behavior and messaging strategies. Weekend travel is more discretionary than weekday travel, and residents of Los Angeles responded rationally to the flood of information before the first closure. Some people likely changed their travel plans to include different modes, routes, or times. Many more, however, either stayed at home or chose to visit destinations closer to home.

It is also clear that travelers absorb information quickly and respond accordingly. During the initial period of Carmageddon I, a large majority of motorists heeded the often

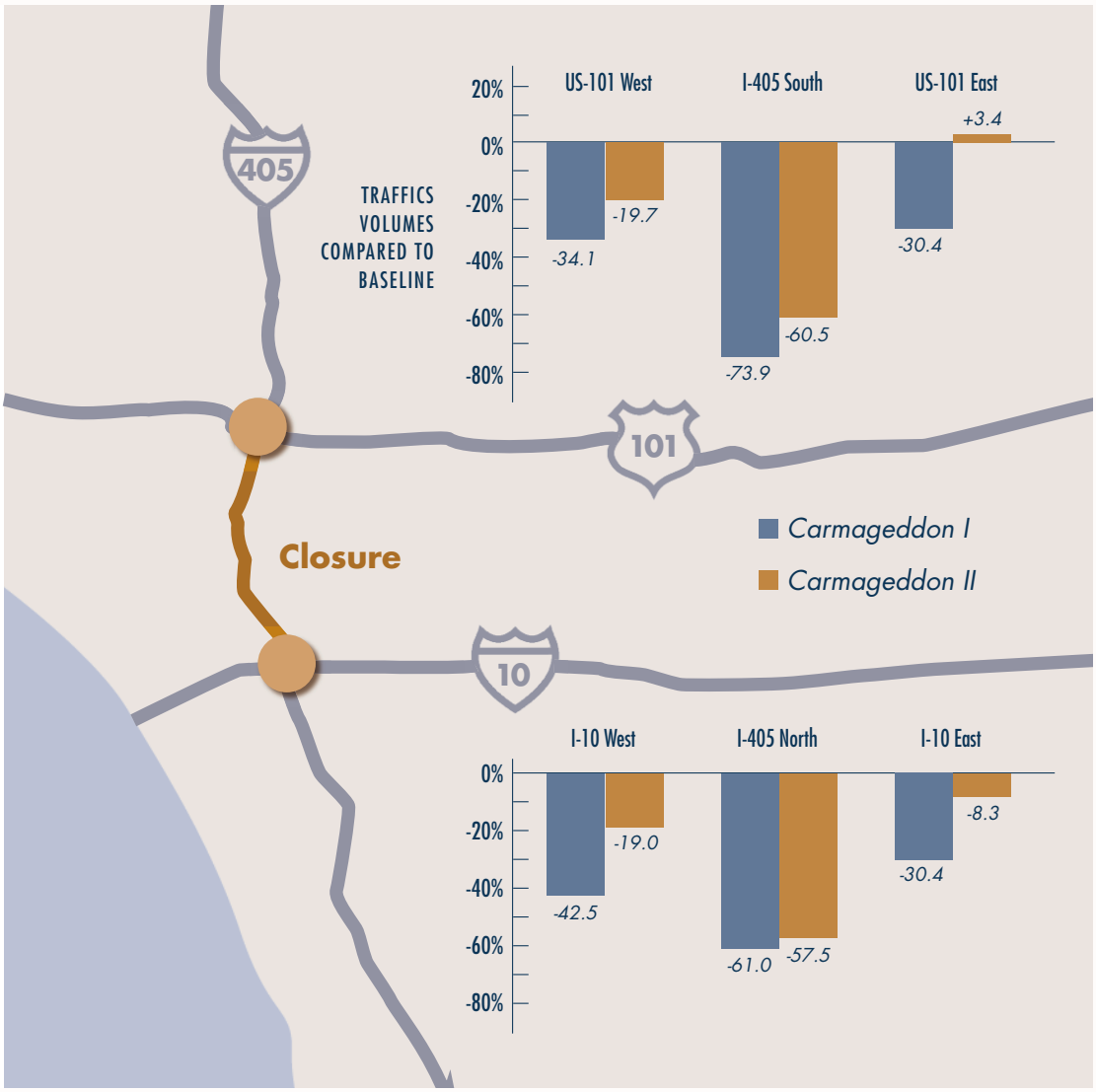

FIGURE 3

Change in Traffic Volumes during the Freeway Closure

dire warnings and stayed off the roads, most likely because: (1) the event took place during the weekend when a larger proportion of trips are discretionary compared to weekdays, and (2) the disruption was relatively short-lived—less than a weekend. As the event progressed and predictions of Carmageddon failed to materialize, motorists adjusted their behavior in response to more sober media reports and real-time traffic information. Some who had originally planned to avoid driving out of fear of nightmarish congestion likely reverted to their more typical driving behavior by taking highway or arterial detours.

Comparing data from the two events provides evidence that travelers learn quickly from information and experience. The dramatic traffic reductions associated with Carmageddon I were not repeated during Carmageddon II. The media messages crying wolf prior to the first closure were tempered in the second, and travelers learned from the first closure that, despite some inconvenience, they could still drive to most destinations.

Travelers were not the only people who learned from Carmageddon I. Given how few travelers chose public transportation as an alternative to the closed freeway, officials ➢

did not waste money on transit enhancements for the second event. Concerned public officials had informed the public of likely nightmarish traffic impacts during the first weekend closure of one of the nation's busiest freeways. The media, without much in the way of supporting evidence, trumpeted doomsday predictions of congestion stretching to the Mexican border 150 miles away and of patients dying en route to hospitals while stuck in traffic. None of these dire predictions came to pass. In fact, the contrast between the perceived threat and reality was so stark that it left the media scratching their heads. One headline read: "Carmageddon in Los Angeles: So what was the big deal anyway?" Another read: "True-life 'disaster' doesn't live up to hype."

During the second weekend closure, transportation officials and elected leaders again appealed for public cooperation, but tempered the messaging. There were many fewer predictions of chaos and more calls for the sort of civic responsibility that had made the first closure a stay-at-home, holiday-like event. The public responded by adjusting travel plans but foregoing far fewer trips than they had during the first closure. Despite fears that the public might ignore pleas to limit travel during the second closure because they were jaded by the lack of traffic chaos the first time, it appears that travelers used the information they were provided to respond appropriately.

Transportation planners can learn much from the two Carmageddons. It's helpful to carefully plan traffic flow patterns by scheduling closures on days when volumes are lower and trips are likely to be discretionary. But disseminating information can also be enormously effective—even more effective than providing alternative travel modes. As real-time information becomes more available to travelers, that information can complement system capacity to reduce cost and delay. Finally, crying wolf presents a dilemma and should be employed judiciously. Going overboard to scare people off of the roads ensures that the promised chaos will fail to materialize, but encourages the traveling public to take future dire warnings with a grain of salt. ◆

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Carmageddon or Carmaheaven? Air Quality Results of a Freeway Closure

ARTHUR WINER, YIFANG ZHU, AND SUZANNE PAULSON

Air quality researchers have recently shifted their focus from regional smog, which has been reduced dramatically over the past 40 years, to the more localized impacts of vehicle emissions near roadways. Numerous studies have linked traffic-related air pollution to a broad range of adverse health outcomes. Concern has focused on black carbon, particles less than 2.5 microns in diameter ($PM_{2.5}$), and ultrafine particles less than 100 nanometers in diameter, small enough to penetrate cell walls and cross the blood-brain barrier. These pollutants may be carried up to 300 meters downwind of major roadways during the day, and more than 2,000 meters downwind in the early morning hours, affecting large populations in major urban centers. By addressing these pollutants, policies to reduce traffic, congestion, and emissions can improve air quality and health. ➢

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Opportunities to directly quantify the relationship between vehicle emissions and air quality by investigating effects of large scale, rapid reductions in traffic are rare. Typically, measures to reduce vehicle emissions and traffic management policies are phased in over years or decades. For example, during the 1996 Olympic Games in Atlanta, peak traffic decreased by around 20 percent and ozone fell by nearly 30 percent, although meteorology may have played a role. During the 2008 Olympic and Paralympic Games in Beijing, the Chinese government enacted air pollution-reducing policies, including traffic restrictions, that resulted in significant reductions in near-roadway emissions. Because emissions from stationary sources were also reduced, traffic restrictions do not fully explain these air quality improvements. In August 2008, New York City closed Park Avenue to vehicular traffic on three consecutive Saturday mornings to promote clean air. This resulted in 58 percent lower ultrafine particle concentrations in the near-roadway environment during the closures.

Overall, there have been few opportunities to test whether reducing traffic (or adopting zero-emitting vehicles) will lead to dramatic improvements in air quality. Although the relationship between traffic and air quality may seem self-evident, it is important to quantify this relationship for key pollutants such as ultrafine particles.

A Valuable Opportunity

In July 2011, Interstate 405, one of the busiest freeways in the United States, was closed for two days as part of a freeway improvement project. Months in advance, the California Department of Transportation (Caltrans) alerted the public to the potential for major traffic jams. The warnings were so dire the media labeled the closure "Carmageddon."

We saw this event as a valuable opportunity to measure the impacts of a major freeway closure on local traffic and to assess the resulting effects on air quality near freeways. We also compared recent ultrafine particle concentrations on a regular weekday with measurements collected in 2001 at the same location. This comparison allowed us to evaluate the efficacy of emission control programs and related transportation policies over the past decade. Lastly, we explored the changes in region-wide air quality as a result of the freeway closure.

Study Design

We set up fixed-site monitors for the key pollutants on both sides of the I-405 freeway along Constitution Avenue, a perpendicular cross street passing under the freeway in West Los Angeles [Figure 1]. In addition, we drove a zero-emissions electric vehicle, with various monitors, along Constitution to measure vehicle-emitted pollutants from I-405 and Sepulveda Boulevard, which runs adjacent to the I-405. We conducted measurements on three consecutive weekends: the weekend before, during, and after the closure.

During the closure, northbound I-405 lanes were completely closed for 16 kilometers (10 miles) between I-10 and US-101, and southbound closures extended for 8 kilometers (5 miles) between US 101 and Getty Center Drive. Sepulveda remained open throughout the shutdown, but Constitution Avenue was closed.

Traffic flow on Sepulveda was video recorded and manually counted. Southbound traffic counts on the freeway at Constitution were obtained from in-road sensors. Local weather data indicated very similar meteorological conditions for the closure and post-closure weekends, while the pre-closure weekend was somewhat different. Therefore, our analysis focuses on comparing the closure and post-closure periods.

FIGURE 1

Fixed-Site and Mobile Monitoring Locations

Results and Observations

On the first day of the closure, there was a 90 percent reduction in traffic on the I-405 at Constitution Avenue compared with a normal Saturday. Similar to the Los Angeles, Atlanta, and Beijing Olympics, the extreme traffic congestion, or in this case "Carmaged-don," never happened. The warnings of catastrophic congestion had been so dire and so relentless that people in the region drastically reduced their driving.

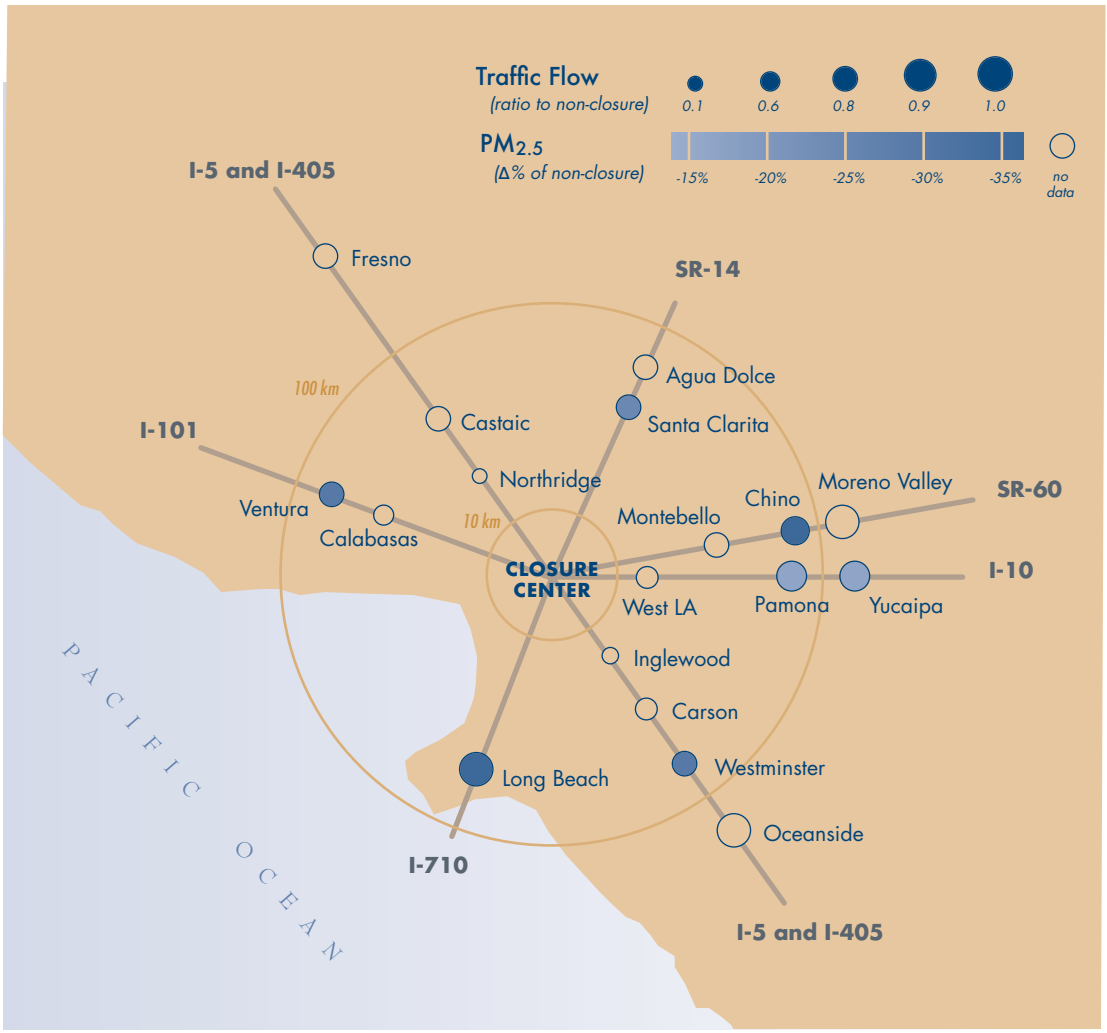
The impact of the Carmageddon warnings extended far beyond the area near the I-405 closure, and even beyond the Los Angeles Basin [Figure 2]. Traffic reductions along the I-405/I-5 corridor were most pronounced, and extended as far north as Fresno (380 kilometers/236 miles), and as far south as Oceanside (160 kilometers/100 miles). The first day of the freeway closure, was the easiest day to get around Los Angeles in decades. Indeed, from a driving standpoint and from an air quality perspective, the term "Carmaheaven" turned out to be more appropriate.

The corresponding improvements in air quality adjacent to the I-405 freeway and Sepulveda Boulevard were dramatic. Compared to the post-closure period, downwind areas experienced an 83 percent reduction in ultrafine particles, 55 percent less $PM_{2.5}$, and 62 percent less black carbon during the closure period. Using the region's air monitoring network, we observed that over the entire South Coast Air Basin, $PM_{2.5}$ was reduced 18 to 36 percent, depending on proximity to the closure.

Our data show that the large traffic reductions associated with the I-405 closure significantly improved air quality. We believe this result provides important evidence in the on-going debate about whether reductions in traffic and/or replacement of combustion vehicles by zero emission vehicles will further improve local and regional air quality. ➢

FIGURE 2

Traffic Flow and $PM_{2.5}$ Changes during Carmageddon



Air Quality and Transportation Policy Implications

As a result of unprecedented long-term air pollution control programs for both mobile and stationary sources, Southern California has experienced dramatically improved regional air quality. This is one of the world's most remarkable environmental success stories. Despite enormous growth—a near tripling in population and more than a tripling in vehicle miles traveled—the region now meets the federal air quality standards for four of the six criteria pollutants regulated under the original Clean Air Act. In addition, the region has reduced peak ozone levels by more than two-thirds.

Between 2001 and 2011, our measurements adjacent to the I-405 freeway show a decrease in weekday ultrafine particle concentrations of approximately 60 to 85 percent per vehicle. This happened despite a lack of direct regulations of ultrafine particles. A modest fraction of the ultrafine particle reduction is due to less diesel truck traffic (from around 5 percent to around 3 percent of total traffic), with the remaining improvement most likely due to fleet turnover, bringing cleaner vehicles into the fleet.

However, despite this impressive progress, it is unclear how to further reduce emissions using only technological innovation to meet current state and federal air quality standards for ozone and $PM_{2.5}$ in Southern California. Thus, the region faces new challenges in reducing the impact of roadway air pollution on human health.

We can infer from this Carmageddon "experiment" that two approaches could dramatically and permanently improve air quality in Southern California. First, transportation policies and alternatives to single-occupancy automobile traffic could be developed to drastically reduce vehicle miles traveled. Second, over time, there could be widespread adoption of super ultralow- and zero-emission vehicles. Of course, it is critical to further reduce or eliminate emissions from not only light-duty vehicles but also from heavy-duty diesel trucks.

As we are atmospheric scientists and not transportation planners, we do not feel qualified to suggest how transportation policies might be developed or what the specific mechanisms may be. However, we do point to our own adoption of a zero emissions electric vehicle to measure air pollutants without interference from our own exhaust. A largely electric fleet could be powered by existing utility sources, charging millions of electric vehicles at night without the need to build any new power plants. However, a truly widespread adoption of electric vehicles will require upgrading the regional electricity distribution system to a "smart grid." In addition, electric vehicles in and of themselves do not address whether the electricity comes from clean or dirty sources.

Finally, we note that beyond the direct improvements in the health of millions of people, many other social, environmental and economic benefits would accrue from reducing vehicle miles traveled and vehicle emissions, and improving fuel economy. Improvements include lower fuel expenditures, less dependence on imported oil, reductions in greenhouse gases, fewer environmental justice concerns, and less congestion, stress, and lost productivity.

Conclusion

Our measurements before, during, and after the Carmageddon/Carmaheaven experiment show definitively that a significant reduction in emissions from light- and heavy-duty motor vehicles results in dramatic improvements in both local and regional air quality. Our observations suggest the air quality standards for ozone and $PM_{2.5}$, which remain unmet in Southern California after more than 40 years, could be achieved with wholesale conversion to zero or near-zero emission vehicles and/or transportation policies to strongly reduce vehicle miles traveled. In addition, these strategies would substantially mitigate the health impacts from vehicle emissions in on-road and near-road environments.

We urge urban planners, transportation policy experts, air quality specialists, the private sector, and environmental justice advocates to work together to develop integrated approaches to protect and improve public health. Finally, we re-emphasize that these approaches must address air pollution at both local and regional levels. The approaches should combat the regional smog problem while reducing the local impacts of vehicle exhaust on commuters and everyone living and working near major roadways. ◆

This article is adapted from "Air Quality Impacts of a Scheduled 36 hour Closure of a Major Highway," originally published in *Atmospheric Environment*. David Quiros, Qunfang Zhang, Wonsik Choi, Meilu He and Rui Wang were important collaborators on the study described in this article. We also thank Kathleen Kozawa and Steve Mara for invaluable assistance with the study. We thank Michael Tsang for the I-405 closure photograph. A portion of the study was supported by the California Air Resources Board, Contract No. 09-357, However the views expressed in this article are not necessarily those of the ARB. Finally, we thank the residents of southern California for staying off the roadways on July 16 and 17, 2011.

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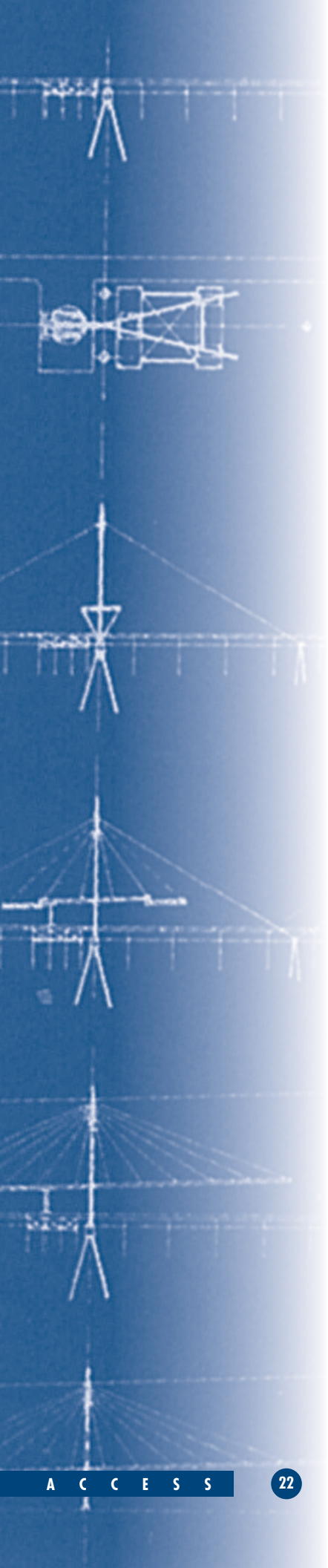

Pursuing the Technological Sublime

How the Bay Bridge Became a Megaproject

KAREN TRAPENBERG FRICK

The newly opened eastern span of the San Francisco-Oakland Bay Bridge is a classic example of a megaproject at $6.4 billion and a textbook embodiment of what I have identified as the "six Cs" of a typical megaproject: *colossal*, *captivating*, *costly*, *controversial*, *complex*, and subject to issues of *control*. Here, I focus on how the "captivating" and "colossal" characteristics affected the bridge design process and implementation. Captivating and colossal projects engage and stimulate participation by a broad set of stakeholders and citizens, whose varied perspectives and inputs can be difficult to accommodate without controversy and conflict. Historian David Nye similarly considered these characteristics emblematic of pursuit of what he termed the *technological sublime*. The technological sublime inspires feelings of "awe and wonder, often tinged with an element of terror, which people have had when confronted with particular natural sites, architectural forms, and technological achievements," like the Grand Canyon, the Empire State Building, and the first transcontinental railroad. In addition to the typical wrangling between actors over specific interests, the pursuit of this feeling of the sublime explains many underlying motivations and rhetoric behind the design process for the eastern span. The period I examine for the new bridge runs from 1997 to 2005, when the major design decisions leading to the final form of the project were made.

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The Public Design Process

The Bay Bridge's eastern span from Oakland to Yerba Buena Island partially collapsed during the 1989 Loma Prieta earthquake. The state of California, which owns and operates the bridge, decided to replace it rather than repair it, since this would give the bridge a longer life and require less maintenance. Governor Wilson and the state Department of Transportation proposed replacing the bridge with a simple viaduct, a long towerless roadway. This offended local architects, planners, engineers, and elected officials who mocked the concept as a "freeway on stilts." As a result, the state left decisions on bridge design to the Metropolitan Transportation Commission (MTC), the Bay Area's transportation planning and financing agency, charging it with addressing these aesthetic concerns. Thus the pursuit of the sublime began, and the Bay Bridge started on its path to becoming a megaproject.

The new east span's design evolved during two cycles of intense public debate. During the first "Regional Mega-Landmark Phase" (1997 to 1998), MTC selected the east span's design. Following the first phase were six years of contentious debates (1998 to 2004) filled with controversy over staggering cost increases and whether the span would be located north or south of the existing bridge. In the next "State Tinker Toy Phase" (2004 to 2005), the state advocated exchanging the tower under construction with another design.

Regional Mega-Landmark Phase

When MTC assumed leadership of the design process, it first established the Bay Bridge Design Task Force, whose seven members were a subset of the MTC board composed mainly of local elected officials. MTC also created the Engineering and Design Advisory Panel (EDAP), a group of 35 experts in bridge engineering, architecture, and geology. The Task Force made its recommendations based on the advice of the EDAP. These advisory panel meetings served as a key arena for debating bridge design and location, including whether to include a rail component, a pedestrian/bicycle pathway, the Transbay Terminal, and bridge ramps to Yerba Buena Island. These debates led to complaints that they were taking the project off track. According to Denis Mulligan, then Caltrans State Toll Bridge program manager: "I always like to point out why we're doing this project…[it] is not a project designed to remove an ugly bridge from the Bay or ➢

Pursuing the technological sublime should be recognized as a potentially critical element in project development.

a project designed to interfere with someone's economic development. It is a public safety project."

From mid-1997 to the end of 1998, MTC and Caltrans held more than 30 meetings, which drew spirited participation from the attendees. The design review criteria that emerged included not only seismic safety components, but also architectural specifications with landmark ambitions, to complement the "elegant" and "graceful" west span, and to compete with the new bridge's chief rival for iconic status, the Golden Gate Bridge.

The Task Force and EDAP first reviewed proposals solicited from a large pool of expert bridge engineers and architects. Later, the field was reduced to two teams within one firm. Most tower designs proposed one or two towers near Yerba Buena Island connected to a long viaduct running to the eastern shore.

A single-tower, self-anchored suspension design won EDAP approval in 1998. Both designs were estimated to cost roughly the same and to have the same seismic resistance. But later interviews with EDAP members revealed that their decisions were also shaped by subjective aesthetic considerations to achieve Nye's technological sublime. The suspension design, they said, echoed both the Bay Bridge's west span and the Golden Gate Bridge, but with a modern flair. The asymmetry of the single tower also placed the main support closer to the solid ground beneath Yerba Buena Island.

In a 1998 EDAP meeting, the late T.Y. Lin, an internationally renowned UC Berkeley engineering professor, commented that a "suspension bridge represents an ignorance in engineering" and that "[the bridge] will be a testament to our ignorance. We'll be the laughing stock of the whole world."

Local elected officials on both sides of the Bay also expressed almost immediate opposition to the single-tower suspension design. East Bay officials wrote to MTC: "[the] design process has not produced a world class design that establishes a sense of gateway and place for the East Bay. The East Bay communities expect and deserve a world class

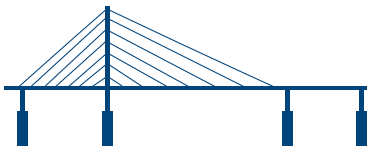
FIGURE 1

Designs Considered for the East Span of the Bay Bridge

Self-Anchored Suspension

- Approved design
- Few existing examples
- Most complicated to construct

Cable-Stayed



- More familiar to builders
- Simpler to construct than self-anchored suspension

Skyway

- Easiest to build
- Does not have a "signature" tower

design that is oriented towards people and provides quality public access and amenities." The *San Francisco Chronicle* and the *San Francisco Examiner* both suggested delaying the decision in order to reconsider design options.

MTC and Caltrans responded to criticism by stating that the Bay's geology dictated the bridge design and tower location. In addition, they argued that it was necessary to move quickly on construction and that further delays would expose more motorists to the risk of a catastrophic seismic event. After much debate, MTC approved the steel single-tower, self-anchored suspension span at a cost of $1.5 billion.

State Tinker Toy Phase

Caltrans, the lead agency charged with overseeing the actual construction of the bridge, conducted the environmental review from 1998 to 2001. It was contentious and drawn out because of disputes over the bridge's location and the perceived impacts of the new east span on Yerba Buena Island's future development.

As Caltrans entered into construction contracts, the bridge's costs rose significantly. In 2004, Caltrans opened bidding for the tower, the bridge's last major component. The single bid for the tower, with estimated costs between $1.4 billion and $1.8 billion, was twice Caltrans' original estimate of $750 million. The bridge's total cost had increased to $5 billion, which Caltrans attributed to rising steel and construction costs, greater-than-anticipated staffing needs, and a longer-than-expected project construction schedule.

In light of the delays and cost increases, Governor Schwarzenegger proposed eliminating the bridge's signature suspension tower and constructing a viaduct instead. His Administration argued that it would trim costs by $300 to $500 million, roughly five to ten percent of the total. The timing of this announcement elicited protests from Bay Area officials, as the bridge's viaduct segment was 70 percent complete, and the tower's foundation was already under construction. Then-State Senator Tom McClintock later stated: "It's the biggest fiasco in California transportation history. This was a simple retrofit of that bridge that has been botched beyond anyone's wildest imagination." ➢

In 2005, after several technical studies, including a review of cable-stayed tower options, Governor Schwarzenegger signed legislation to construct the east span with the originally selected suspension tower. The Bay Area was responsible for covering much of the capital costs through toll increases and refinancing. The Bay Area also agreed to assume major oversight responsibilities for the state-owned toll bridge program. The new tower's contract was awarded to a joint venture between the American Bridge Company and Fluor Enterprises in 2006, nearly two years after the original bid. The east span's price tag was $6.4 billion, a far cry from the $1.5 billion replacement estimate in 1998, and even further from the $250 million retrofit estimate in 1996.

Observations and Recommendations for Megaprojects

The new Bay Bridge raises several important considerations for policy analysts of megaprojects. First, as governments plan future megaprojects, it is important to recognize that the pursuit of the technological sublime may derail public processes and negatively affect a project's design, budget, and schedule. Participants may be blinded by an overly optimistic belief that design and engineering can overcome the technical complexities and risks associated with implementing large-scale projects. Yearning for the sublime, however, can also fuel creative solutions and stimulate public involvement because of the visionary nature of the project.

Second, the Bay Bridge case calls into question the appropriateness of using public money to fund aesthetics. The Bay Area elected to construct a signature bridge at a higher cost rather than a utilitarian viaduct. The region's choice generates a set of interesting policy questions for megaprojects, as well as other publicly funded projects in general. Should the government invest in aesthetics beyond the basic design of such a project? Is it reasonable to argue for an aesthetic value in simplicity and cost minimization? Should the agency paying the basic costs have the full responsibility for the extra aesthetic costs, or should agencies that benefit from the imagery bear the additional cost? Further, if costs increase, how do agencies cover these additional costs?

Overall, pursuing the technological sublime should be recognized as a potentially critical element in project development, whether or not the designs result in enduring landmarks and engineering marvels. As the Bay Bridge case reveals, the quest for the sublime provides participants with the personal motivation and interest to engage in the process. Agencies should acknowledge, however, that pursuit of the sublime can create unpredictable and chaotic processes, turning projects into megaprojects. ◆

This article is adapted from "The Cost of the Technological Sublime: Daring Ingenuity and the New San Francisco-Oakland Bay Bridge," originally published in *Decision-Making in Mega-Projects, Cost-Benefit Analysis, Planning and Innovation.*

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We Can Learn Something from That!

Promoting an Experimental Culture in Transportation

JOSEPH SCHOFER AND RAYMOND CHAN

Decision makers need to know what works and what doesn't in order to make informed choices about transportation investments. Hard evidence, rather than opinions, should be the source of this information. Making use of hard evidence, though, can be challenging when transportation proposals come from policy makers who have already made a public commitment to an idea, such as building a high-speed rail system. Presenting new information on such vision-driven projects may mean confronting, and perhaps contradicting, established political positions. Nonetheless, evidence on what works is vital to making wise transportation decisions. Experiments are the most effective way to show what works—or might work—in a given setting, especially when the experimental conditions are close to the decision situation at hand. Experiments vary in validity and transferability, but opportunities to experiment with transportation are all around us.

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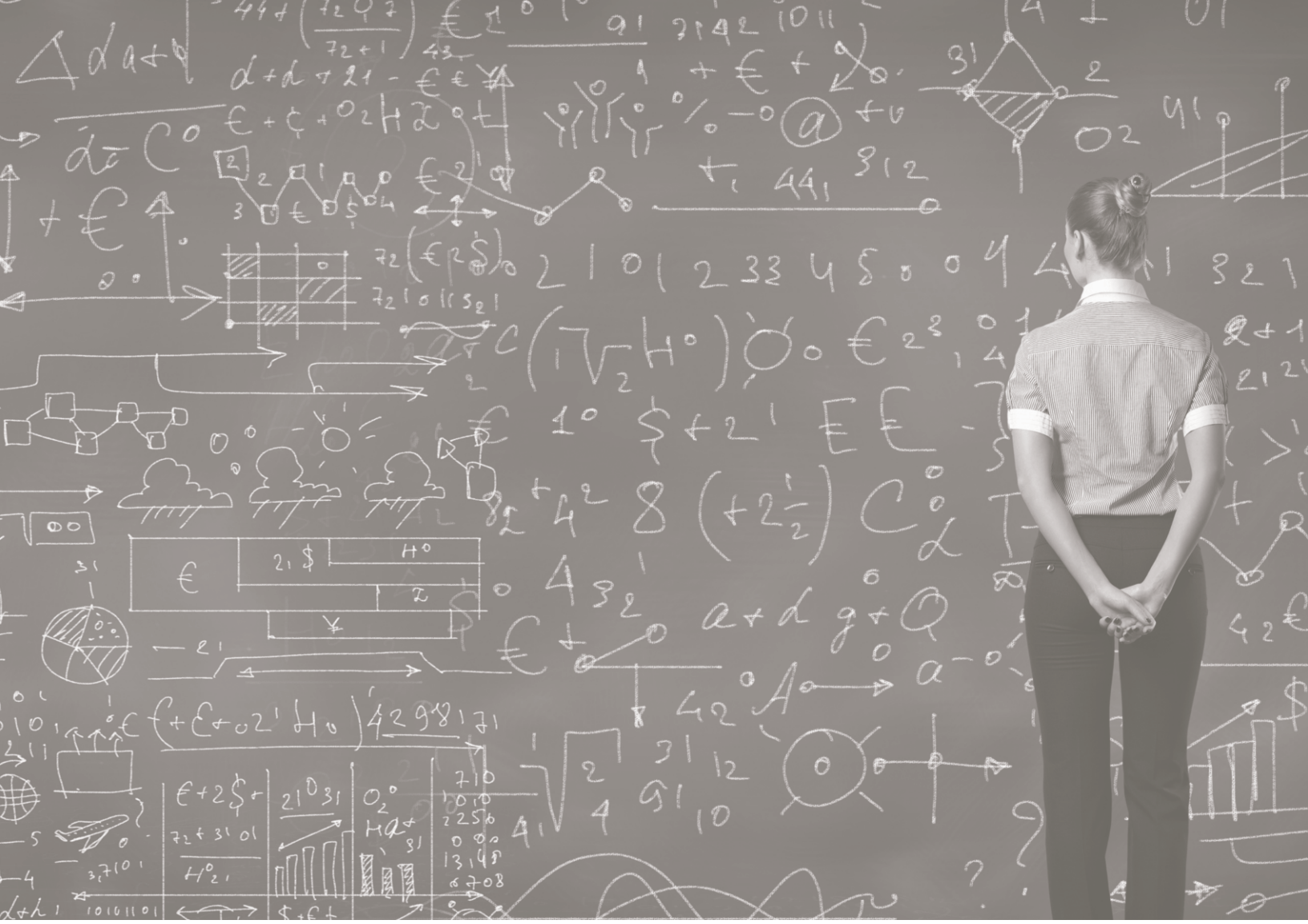

Four Types of Experiments

Planned and unplanned changes in transportation systems occur all the time. If we study them as experiments, there are opportunities to answer causal questions and to learn what works and what doesn't. We can learn from four kinds of experiments: laboratory experiments, analytic models, field experiments, and natural experiments.

Laboratory Experiments

The lab allows us to test the feasibility and performance of new technologies and innovations such as engines, fuels, sensors, or crash protection systems. We can use simulations or focus groups to explore factors affecting human behavior, including the effects of cell phone distractions on driver performance, or reactions to new service concepts for public transit. Laboratory experiments can only answer narrowly-defined questions, however, and cannot address large scale feasibility issues, such as market and political responses, implementation issues, or longer term economic and environmental consequences. Additionally, transportation decision makers may find lab results to be too distant from reality, particularly when results conflict with their prior opinions. ➢

Opportunities to experiment with transportation are all around us.

Analytic Models

Models allow planners to experiment with designs and service concepts without the expense or safety constraints of field experiments. Modeling has long been a core activity of transportation planning and is most commonly used to analyze demand and network equilibrium. Model-based experiments are imperfect, however, and subject to biases, most notably when forecasting travel demand and system costs. Models extrapolate behaviors of systems and the people who interact with them, so they have limited ability to test substantially new concepts. Because of these limitations, analytic models may not be the best tool for decisions about large investments or radical service changes. Decision makers may discount the credibility of models, as they do for lab experiments.

Field Experiments

Planners can conduct field experiments when they implement new systems or services and observe the outcomes. The results of real-world experiments are more complex and nuanced than the outcomes of laboratory or model-based experiments. The real world is richer and more credible, and thus outcomes are more convincing and harder to dismiss. During the planning process, transportation decision makers commonly look for concrete examples and are influenced more by experiences and observations than by forecasts and reports.

People often look to other places for guidance, asking questions like, "Why can't we have high-speed rail like they have in Europe?" Planners and decision makers should certainly learn from what others have experienced, but they should also exercise caution because results of field experiments are not always transferable. What works in Paris may not work in Los Angeles. If we look only for what we want to find, the risk of confirmation bias can outweigh the benefits of learning from others' field experiments.

Natural Experiments

Natural experiments often arise in the form of uncontrollable events, such as hurricanes, floods, storm surges, heavy snowfalls, and drought. These extreme weather events probe the vulnerabilities of infrastructure and service systems and test our defense and response mechanisms. Mother Nature has ways of finding out where we are weak by conducting stress tests we would never voluntarily undertake. Nature's experiments sometimes uncover vulnerabilities that might lead to serious problems in the future if we experience significant rise in sea level, more frequent and severe flooding, prolonged droughts, or heat waves. Recent unexpected outcomes have included:

- Commuter rail lines washed out when a privately-owned dam failed in hurricane-driven rains (Metro-North Port Jervis Line, 2011)
- Reduced pavement life resulted from prolonged submersion in flood waters (Nebraska, Missouri, and Platte Rivers, 2011)
- Train derailments and infrastructure damaged by an extended heat wave (Northbrook, Illinois, 2012)

The lessons learned from these natural experiments can guide preparations for the future, inform and motivate adaptation strategies, and reduce both risks and costs in the long run. Importantly, they may build support for actions that address extreme and uncertain natural events.

Creating a Culture of Experimentation

We can learn more about the vulnerability of our transportation systems and what projects and policies work by establishing a culture of experimentation that both initiates field experiments and capitalizes on selected natural learning opportunities. In particular, there is a special incentive to turn major natural disasters into learning experiments that help us prepare for future extremes.

Learning from Nature

Opportunistic learning from nature is a particularly important way to address the potential consequences of climate change and natural disasters such as earthquakes and tsunamis. For example, after Hurricane Katrina devastated the New Orleans area, several studies were conducted to understand the vulnerabilities in southern Louisiana. At-risk organizations elsewhere also learned from this natural experiment. The New York Metropolitan Transportation Authority (MTA) developed its own hurricane-storm surge response policies, adding lessons from Katrina to its experience with the heavy snowstorm that stranded buses and trains in New York in December 2010. These natural experiments ➢

Mother Nature has ways of finding out where we are weak by conducting stress tests we would never voluntarily undertake.

informed MTA's policies that called for shutting down mass transit services in the face of Hurricane Irene in 2011 and the much stronger Hurricane Sandy in 2012, saving countless lives and dollars.

We do not choose the time and place for such events, but we can learn from them. We must have mechanisms in place both to capture data and to provide flexibility to direct resources to analyses and interpretations. Agencies affected by extreme weather events sometimes conduct *post mortem* evaluations to prepare for future events—exactly what happened in New Orleans after Katrina and New York after Sandy. While these have high value for local use, national learning may call for more broadly focused and systematic assessments. Figure 1 presents a checklist that could be a starting point for planning and learning from experiments in anticipation of extreme weather events. The most important steps will assure that the necessary data are collected and preserved to support maximum *post hoc* learning.

Turning Events into Experiments

The national interest in experimenting grows when projects have the potential to guide major decisions. Investments in high-speed rail (HSR) are an important example.

HSR proposals have generated both broad interest and substantial controversy. Uncertainties associated with HSR investments include costs, performance, market response, and finance mechanisms. California's program may offer the best opportunity to gather critical, US-based evidence to inform future HSR choices. Because HSR projects are planned interventions, they can be structured as experiments from the outset to increase their value as learning tools.

To view California's HSR program as an experiment, it makes sense to focus federal dollars in one place to conduct a meaningful test, rather than follow the political tradition of spreading federal funding over multiple small or partial projects across the nation. Furthermore, HSR projects are typically built in stages, which can expedite the first opportunities for learning from them. The resulting knowledge benefit will be greater, and will come sooner, if the initial stage can target major topics of uncertainty, such as market response and financing. If the HSR system is built in corridors where there is substantial demand potential, we have the opportunity to learn about the market response, the resulting revenue stream, and the interests in investing future public and private funds in HSR. This strategy would generate lessons more quickly and contribute to the reduction of long-term national investment risk.

Sharing the Data

Collecting, archiving, maintaining, and sharing data form the foundation for experimentalizing projects and events. Cities archive data to assess long-term outcomes, such as shifts in land use, environmental consequences, and individual and organizational travel behaviors. Archived data also helps to answer questions that may arise in the future. The volume and scope of data now collected are rapidly expanding because of innovations in Intelligent Transportation Systems and social media. The increasing breadth of available data is balanced by the steady decline in storage costs.

Data sharing opens the door for many researchers to analyze experiments and, through replication, to test the findings of others. Such replication can provide more robust, and sometimes different, interpretations of experiments. Data sharing can be contentious

1. **Preparation for learning:**
   - What is the system of interest?
   - What are the threatening events — flood, storm, drought?
   - What do we want to learn from them? System vulnerability, effectiveness of management response, resilience of systems and people, better options for the future?

2. **Data collection:**
   - What should be measured and how should data be collected by event phase?
   - How can we take advantage of data that are routinely collected to minimize incremental data costs?

   a. Preparation:
      - What actions were taken to prepare?
      - What warnings were disseminated?
      - How did the public respond?

   b. During event:
      - What was the scope and scale of the event?
      - What agency actions were taken?
      - What service interruptions and damage to infrastructure and rolling stock occurred?
      - What were customer behaviors and responses?

   c. Recovery period:
      - What did it take to restore service — time, effort, money?
      - How did customers respond?
      - How did the press and leadership respond?

3. **Analysis and interpretation:**
   - What lessons were learned — good and bad?
   - What can be done better in the future for infrastructure, forecasting, warning, operations management, and recovery planning?

4. **Adaptation actions:**
   - What policy and system changes should be made in response to lessons learned?

FIGURE 1

Nature's Experiments: Steps for Learning from Extreme Weather Events

because of privacy concerns as well as proprietary interests in publication primacy. These issues have become prominent in behavioral research as the ability to collect highly personalized, microscale data has exploded.

When there is broader interest in the outcome of an experiment, it may be appropriate to assemble resources at the national scale to invest in extra data collection, analysis, and interpretation. Support for experiments of broader significance might come from federal or pooled state funds. For example, the American Association of State Highway and Transportation Officials sometimes provides funds to address problems of interest to multiple states. Providing national support for experimentalizing projects requires not only a source of funding, but also an objective mechanism for selecting those projects. ➢

Conclusion

Academic programs and professional organizations may be best positioned to conduct experiments because they are already equipped to evaluate them. They also are able to define standards and templates for data collection, establish principles for data stewardship and sharing, develop practical methods for experimental design, conduct meta-analyses of findings from multiple studies, and promote peer review to enhance the quality of experimental studies.

Federal and local institutions should work to support an experimental culture by promoting the value of learning from experience. Local learning, in particular, brings high value to local transportation decision making because it reduces the "not invented here" reaction—"owned" results are harder to ignore. Government investment in experimentation should include not only incremental funding within established action programs, but also a policy commitment to planning experiments, collecting, archiving and sharing data, and using the results in decision processes.

Creating an experimental culture will help us learn more, faster, through systematic studies of changes from within and threats from without. Ultimately, this will help to create a better transportation future for everyone. ◆

This article is adapted from the Melvin Webber Lecture given at UC Davis in 2012. Special thanks to William L. Garrison, University of California, Berkeley, whose ideas about experimentation helped motivate this work.

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Parking Charity

DONALD SHOUP

In December 2010, the City Council of Berkeley, California, voted to give what they thought was a generous Christmas gift to the city's merchants: free parking at all parking meters in the city. "There are a couple of messages going out here," said councilmember Laurie Capitelli. "One is that we are inviting customers to our commercial districts. Two, we're sending a message to our small businesses, saying 'we are hearing your concerns, and we do want to respond to them.'"

The Downtown Berkeley Association cheerfully informed its members, "There will be no pay and no time limits! And, remember that this is a gift to our customers. Please tell your employees to leave this space available for customers." Berkeley's city manager estimated that the city would lose between $20,000 and $50,000 in meter and ticket revenue for each day of the meter holiday.

Merchants may thank elected officials for free parking at the time of peak demand, but open spaces will become even harder to find. Drivers congest traffic and pollute the air while searching for curb spaces, and the lucky ones who find a space will occupy it longer than if they were paying to park. Parking holidays are well-intended, but the gift is more like a lump of coal for businesses that depend on parking turnover. ➢

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Creating a Commons Problem at Christmas

Free curb parking creates a classic commons problem—no one owns it, and everyone can use it. In his famous essay, "The Tragedy of the Commons," Garrett Hardin used free curb parking at Christmas to illustrate the problem:

> During the Christmas shopping season the parking meters downtown were covered with plastic bags that bore tags reading: "Do not open until after Christmas. Free parking courtesy of the mayor and city council." In other words, facing the prospect of an increased demand for already scarce space, the city fathers reinstituted the system of the commons.

Hardin also used parking meters as an example of social arrangements that encourage responsible behavior:

> To keep downtown shoppers temperate in their use of parking space we introduce parking meters for short periods, and traffic fines for longer ones. We need not actually forbid a citizen to park as long as he wants to; we need merely make it increasingly expensive for him to do so. Not prohibition, but carefully biased options are what we offer him.

Despite the need to manage parking demand during the peak shopping season, many cities continue to wrap their parking meters in December, giving motorists a commons problem for Christmas. Consider the program in Bellingham, Washington:

> This year, for the two weeks before Christmas the city will offer all-day free parking.... To help shoppers park close to businesses and keep spaces available, the city is asking that people still observe the time limits at meters. Shoppers planning to be downtown for more than a couple of hours are encouraged to park on the ground floor of the Parkade.

Free curb parking will not "keep spaces available," and few motorists will comply with the request to "still observe the time limits at meters." Meter holidays invite commuters to park free all day in metered spaces, leaving less parking for customers.

Although well-meant, meter holidays create a shortage of curb parking at the busiest time of year, making it more difficult for shoppers to find a curb space and exacerbating traffic congestion. Consider this report of what happened when Durango, Colorado, bagged its parking meters at Christmas time:

> As sleigh bells ring and the countdown to Christmas comes to a close, the city has been promoting free downtown parking for holiday shoppers.... But there is just one small problem: There's nowhere left to park.... Cuenca said he has noticed some motorists driving dangerously, pulling aggressive maneuvers to secure their spot before spreading commerce and holiday cheer. "It's created a frantic frenzy just to find a spot."

Harnessing the Seasonal Urge to Help Mankind

Rather than provide free parking, cities could instead post signs during the Christmas season saying, "*The city will donate all parking meter revenue in December to pay for food and shelter for the city's homeless population.*" Shoppers might like this more than a parking holiday that makes it harder to find a curb space. They might also feel better about paying to park downtown if they know their money is going to help the homeless. Parking charity rather than meter holidays will help those in greatest need, prevent parking shortages, and aid businesses that depend on curb parking. Wanting free parking for Christmas will begin to look quite greedy.

Parking charity can extend beyond the Christmas season. Many stores and malls reserve the most convenient parking spaces for disabled access, but able-bodied drivers sometimes park in them. To deal with this problem, and to provide spaces for all drivers who want quick access, a store can install parking meters in a few spaces adjacent to the disabled spaces, while keeping all other spaces in the lot free. To justify this policy, the store can place a sign on every meter saying that all the revenue will be donated to charity.

The prices for the charity meters can be set at a level that will keep one or two spaces open, allowing able-bodied drivers to park in convenient spots without harming disabled shoppers. Able-bodied drivers who do park in disabled spaces will look even more contemptible if they can instead donate to charity at a nearby meter.

Some drivers may be happy to pay for convenient parking when they really want it. Suppose the charity meters charge $1 an hour. A driver who is in a hurry to make a quick purchase and who parks for only 15 minutes might not mind donating 25¢ to charity to park near the front door, while a driver who parks for four hours can park farther away and save $4. A higher turnover of cars in the charity spaces will also benefit the store because customers who park in them will probably spend more per minute while they are in the store. And customers who walk past the charity meters might applaud the store's altruistic parking policy.

If cities donate their meter money to charity during the Christmas season, and if stores place a few charity meters in their most convenient spots, drivers will begin to see that charging for parking can do some good for the world. Only a Grinch would demand free parking for Christmas. ◆

Wanting free parking for Christmas will begin to look quite greedy.

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