REBUILDING AMERICA'S **INFRASTRUCTURE**

MARKET-BASED IDEAS FROM THE MANHATTAN INSTITUTE

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INTRODUCTION

American infrastructure is in dire need of repair and replacement. Yet decades of experience have shown us that simply showering federal money on infrastructure is not the right solution. Indeed, this approach has been shown to encourage wasteful spending on projects that are politically expedient but economically dubious. Large injections of federal funds may encourage spending money on large, new projects while ignoring critical maintenance backlogs on existing infrastructure. Or it may incentivize state policymakers to devote attention to particular communities whose political importance far outweighs their need for new infrastructure.

But despite these pitfalls, the federal government does have a role to play in revitalizing our country's highways, airports, rail networks, pipelines, electrical grids, and water infrastructure. Over the following pages, Manhattan Institute scholars from a variety of different areas of expertise will sketch what, precisely, that role is. Among their recommendations:

KNOW THE LIMITS OF PRIVATIZATION

Given all the hurdles associated with the public sector, many have argued that private enterprise should play a larger part in infrastructure provision. While there is space for an increased private role—especially when it comes to America's airports—handing control of infrastructure provision to the private sector isn't always the answer. Harvard economist Ed Glaeser's essay, "Private Infrastructure Provision: The Easy, The Hard, The Impossible" powerfully demonstrates why: privatization makes sense for new, "green field" projects that are likely to generate revenue; it is much harder to locate a role for the private sector in the maintenance of existing infrastructure, which tends not to generate profit yet is the country's most pressing infrastructure need.

DECENTRALIZE INFRASTRUCTURE FINANCING AND MANAGEMENT

Glaeser's second contribution to this series, "If You Build It," addresses the all-too-common problem of political leaders setting bad infrastructure priorities. New infrastructure investment, Glaeser argues, is best suited to economically expanding places. But too often, politicians prioritize new projects in declining areas where the expenditures can't be justified on economic grounds. His solution: send more of the authority to make these decisions back to local communities.

PRIORITIZE HIGH-VALUE INVESTMENTS

A series of three articles by City Journal contributing editor Nicole Gelinas, all originally published in the New York Post, present some of the most high-value infrastructure projects that the Administration should prioritize. Some of the most important projects include the Gateway tunnel between New York and New Jersey and an interstate highway between Las Vegas and Phoenix. Gelinas argues that policymakers should not worry about borrowing money to fund projects that will pay for themselves, and that the federal government should reward states and cities that have reasonable work rules and a demonstrated history of managing large projects well.

FIX THE HIGHWAYS WE HAVE BEFORE BUILDING NEW ONES

With 20% of the nation's roads in poor condition, and the total number of miles driven annually by Americans stagnant, now is not the time to build new highways, writes MI Senior Fellow Aaron Renn in his report "Driverless Cars and the Future of American Infrastructure." And because of technological innovations such as the self-driving car, the number of cars on the road—and the demands we will have on our highways—are unpredictable. With so much uncertainly ahead, policymakers should maximize the value of their infrastructure investment by fixing the highways we already have.

PRIVATIZE AIRPORTS

Many of the world's best airports are run privately, or through public-private partnerships; meanwhile, in the United States, our airports are lagging behind. Flight delays are rampant and the quality of the airports themselves are often "third world," as former Vice President Biden famously quipped. City Journal contributing editor John Tierney, in his profile of the mismanagement, bloat, and corruption at New York City's airports, "Making New York's Airports Great Again," makes a compelling case for privatization nationwide.

BREAK UP THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

The Port Authority of New York and New Jersey, which controls much of the critical infrastructure in the country's largest urban center, is corrupt, unwieldy, fiscally unsound, and incompetent. Robert Poole, founder of the Reason Foundation and contributor to a series of Manhattan Institute research on the Port Authority, puts forth a plan for breaking the entire entity up, entitled "Reinventing the Port Authority of New York & New Jersey." A federal infrastructure plan should have incentives for the Port Authority to break apart each of its functions, which include management of a rail transit line, a bus terminal, several airports, and all of the bridges and tunnels across the Hudson River, into separate entities

CLEAN UP THE EPA'S WATER MANDATES

The federal government currently requires cities to undertake massive projects to retrofit their "combined sewers" (sewers in which storm-water runoff and sanitary waste from buildings are channeled into the same pipes to reduce or eliminate overflows of untreated wastewater into local waterways). The cost of these projects often run into the billions, yet the federal government provides almost no funding support. Aaron Renn's second contribution to this series argues that the EPA should revisit this mandate, and that the federal government should step in to provide more support to cities struggling to complete these projects.

MAKE THE ELECTRICAL GRID MORE SECURE, NOT GREENER

One of the major trends in energy policy has been the move toward "green" grids—electrical grids whose deployment involves a vast expansion of the Internet of Things to achieve energy efficiency goals. But connecting the grid to the internet makes it far more vulnerable to cyber attacks. And while the federal government spends massively on grid efficiency technology, it spends next to nothing on grid security. MI Senior Fellow Mark Mills, in "Exposed: How America's Electric Grids Are Becoming Greener, Smarter — and More Vulnerable," argues that the government should prioritize grid reliability and resiliency above all other goals.

INFRASTRUCTURE

PRIVATE INFRASTRUCTURE PROVISION—THE EASY, THE HARD, THE IMPOSSIBLE

EDWARD L. GLAESER

There are many things to like about President-elect Trump's plan to encourage the private provision of infrastructure. Private firms have incentives to keep costs down. If the costs need to be covered by tolls and ticket fees, no one would build bridges to nowhere or empty monorails. If investors reap returns only over time, they have the right incentives to invest in maintenance.

But private provision is no panacea. In some cases, such as airports, privatization can be swift and relatively painless. Yet generous tax credits for privately built infrastructure—as proposed by Wilbur Ross, Mr. Trump's nominee for secretary of commerce—leave real potential for abuse: when the users don't need to cover costs, it is far easier to waste billions on unwise projects. Better to make tax credits dependent on project performance, as measured by property-value increases. Unfortunately, privatization is unlikely to be the right recipe for America's most important infrastructure investments: maintaining its existing stock. A better approach would have the federal government monitor infrastructure quality and tie federal support to maintenance.

[1] For further discussion, see Edward L. Glaeser, "If You Build It… Myths and Realities About America's Infrastructure Spending," City Journal, Summer 2016.

1 THE EASY: AIRPORTS AND NEW TECHNOLOGIES

The world has plenty of well-run privately owned and operated airports, such as London's Heathrow. Yet New York City groans with the service provided by La Guardia Airport and JFK, which are part of the publicly owned and operated Port Authority. President-elect Trump should follow Prime Minister Thatcher's lead and push to privatize airports that function poorly.

Airports are easy targets: they don't need subsidies, and there are many global models for airport privatization. Air passengers generally have above-average incomes and can readily pay landing fees sufficient to cover the costs of the airport. JFK could certainly survive as a stand-alone business. Indeed, metropolitan New York is a natural place to start with airport privatization: the current service level is low, and the region's three major airports make the market naturally competitive. This competition should act to keep service level high and prices low. (Where only one airport serves a region, there is a better case for some regulation of landing fees.) Airports still need regulation. We want the TSA to continue screening—although it would be best if passengers fully pay for its costs. Ordinary taxpayers in Nebraska should not pay for the security costs of highfliers in New York.

In addition to privatizing airports, there may be other easy wins for the new administration that leverage America's edge in new technology. Taking advantage of new transportation technologies often requires new infrastructure. The full advantage of steam engines wasn't reached until we had built thousands of miles of rail lines. Cars needed the highway system.

Mr. Trump should convene a high-level Transportation Technology Council to discuss how the federal government can—ideally, without subsidies—enable the proliferation of new transport options. Do we need help coordinating electronic charging stations? Do we need new rules about vertical takeoff and landing planes in cities? Do we need separate lanes on highways for autonomous vehicles? The president-elect should embrace the possibilities and start a planning process for the future.

2 THE HARD: GETTING SUBSIDIES RIGHT

Mr. Trump has expressed admiration for Peter Navarro and Wilbur Ross's plan to subsidize privately delivered infrastructure. The Navarro and Ross plan imagines that private infrastructure investment would be supported by public tax credits, like the Low Income Housing Tax Credit, which subsidizes affordable housing.

Private Activity Bonds provide an alternative model, one that subsidizes transportation construction by allowing private companies to issue tax-exempt securities. These bonds are allocated by the Department of Transportation to projects like I-495 Capital Beltway High Occupancy Toll lanes.

Yet public subsidies for private investment create new perils for waste and abuse. The Navarro and Ross plan assumes that the "government will provide a tax credit equal to 82 percent of the equity amount" of investment in new infrastructure. They correctlysay that this still "leaves the investor with skin in the game"—though not a lot. Moreover, whenever there are generous subsidies available for private businesses, those businesses have strong incentives to invest in gaming the political process.

While the Navarro and Ross plan avoids technical jargon, their basic economic argument is not specious. New infrastructure can create "externalities"—benefits that are not reaped by the investors themselves. Consequently, the socially desirable amount of infrastructure is greater than the amount of infrastructure that private investors will produce on their own. Navarro and Ross focus on the benefits that infrastructure creates through added property- and income-tax revenues.

Still, countless wasteful public investments were based on the alleged externalities from new building. Detroit's infamous People Mover Monorail, for instance, was supposed to work magic in the city. It didn't.

Equity investors are sure to love a system where the government pays 82% of their costs while investors get the upside. This is the kind of heads-I-win, tails-the-government-loses scenario that made such mischief in the mortgage-backed securities market before the Great Recession.

The downsides of the Navarro and Ross scheme could be reduced by making tax credits contingent upon performance. If the justification for these subsidies is that infrastructure projects will generate property-tax increases, the credits should be contingent upon increases in property values.

For every new project, define a catchment area that will potentially benefit from the new infrastructure; then define a comparable control region that is not likely to benefit from the project. The increase in property-tax revenues for the catchment relative to the control area provides the natural measure of the size of the external benefit from the project.

If the tax credit is proportionate to the increase in property-tax revenues and is doled out over time, the potential for abuse is significantly reduced. Savvy investors will invest only in projects that

are likely to lead to large increases in local property values, and those are

the new projects that make the most sense. A further check on tax-credit abuse is to share the cost among states, localities, and the federal government. Most of the benefits of new infrastructure projects lie within a single state. Federal support should be a fraction of the total tax credit and should flow only when states are also willing to pony up cash.

The federal government can further support local projects by helping states and localities to evaluate regulations, including land-use laws that can prevent new infrastructure from being built.

The Federal Office of Information and Regulatory Affairs provides cost-benefit analysis for executive-branch regulations; but states and localities are too small to have their own cost-benefit analysis shops.

The federal government could help by providing cost-benefit analysis for state and local regulators—and tie tax credits to the use of federal cost-benefit analyses. If the states want the money, they need to submit to an analysis that will ensure that local regulations aren't increasing costs excessively.

3 THE IMPOSSIBLE: PRIVATE MAINTENANCE OF EXISTING INFRASTRUCTURE

For decades, transportation economists have emphasized that the highest returns come from investing in existing infrastructure. In some cases, this means repairing potholes and ensuring the structural integrity of a bridge. In other cases, this means imposing smarter tolls that vary by time of day to ensure more efficient usage.

In theory, privatizing some roads, bridges, and tunnels will solve these problems. A private provider will have incentives to ensure that the road doesn't become unusable. A private toll company will be happy to impose time-varying tolls to make a road more attractive and profitable.

Yet throughout much of America, privatization is politically unlikely and tolling is deeply unpopular. Like government, private providers may skimp on safety, especially when the benefits from spending on maintenance are not always immediately obvious to drivers. Still, the federal government can help with the repair of existing infrastructure. It can regularly monitor road quality and bridge safety. Improvements in technology have made this easier than ever. It is possible to use drones to photograph roads, and computer vision can now spot potholes from pictures. Bridge and tunnel safety are a little harder to assess, but doable.

In addition to carrots, there are sticks. For example, if a state's infrastructure is in poor shape, the federal government can refuse to support building new infrastructure until the existing infrastructure is brought up to snuff. Or it can withhold tax credits and require federal highway funds to be used only for maintenance. Or if current tolls are too low to pay for maintenance, it can insist on higher user fees.

When existing infrastructure quality rises above a threshold, some new infrastructure support is feasible; but still, the lion's share of state spending needs to go for maintenance to be eligible for federal support. The key is that the federal government transforms itself from an uncritical funder of new projects to a watchdog that insists that states maintain their existing infrastructure stock.

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IF YOU BUILD IT...

MYTHS AND REALITIES ABOUT AMERICA'S INFRASTRUCTURE SPENDING

EDWARD L. GLAESER

Among Bernie Sanders's many proposals during his presidential run was a plan for Washington to spend **$1 trillion on public infrastructure.** Progressives love such proposals. Just tax the rich enough, they say, and we can build superfast trains, new roads, revamped airports, and other things that (purportedly) will bring widespread prosperity and greater equality from California to Montana to Maine. President Barack Obama has done his best to further this vision. He began his first term pumping $48.1 billion into infrastructure spending, via the 2009 American Recovery and Reinvestment Act (otherwise known as the stimulus package), and is ending his second term with a proposal to spend $73 billion more on infrastructure.

The progressive romance with infrastructure spending is based on three beliefs. First is that it supercharges economic growth. As President Obama put it in his 2015 State of the Union address: "Twenty-first century businesses need twenty-first century infrastructure." Further, by putting people to work building needed things, infrastructure spending is an ideal government tool for fighting unemployment during recessions. Infrastructure should also be a national responsibility, progressives believe, led by Washington and financed by federal tax revenues.

None of this is right. While infrastructure investment is often needed when cities or regions are already expanding, too often it goes to declining areas that don't require it and winds up having little long-term economic benefit. As for fighting recessions, which require rapid response, it's dauntingly hard in today's regulatory environment to get infrastructure projects under way quickly and wisely. Centralized federal tax funding of these projects makes inefficiencies and waste even likelier, as Washington, driven by political calculations, gives the green light to bridges to nowhere, ill-considered high-speed rail projects, and other boondoggles. America needs an infrastructure renaissance, but we won't get it by the federal government simply writing big checks. A far better model would be for infrastructure to be managed by independent but focused local public and private entities and funded primarily by user fees, not federal tax dollars.

Building infrastructure is no surefire way to stimulate economic growth, as Japan's example shows. After decades of strong economic expansion, Japan experienced a massive asset bubble in the late 1980s, with the Nikkei 225 reaching 38,500 in December 1989. The next year, the bubble burst and the index began falling precipitously, dipping below 15,000 by August 1992 and never recovering—indeed, by 2001, it had dropped below 10,000. Even today, the index is only slightly above 17,000. Japan's dismal stock-market performance has been matched by little or no economic growth. Per-capita GDP, in constant U.S. dollars, was no higher in 2009 than in 1991, according to OECD data. The Japanese economy picked up slightly this year, but it's fair to say that Japan has lost a quarter-century of growth.

To help fight this economic sluggishness, Japan has invested enormously in infrastructure, building scores of bridges, tunnels, highways, and trains, as well as new airports—some barely used. The New York Times reported that, between 1991 and late 2008, the country spent $6.3 trillion on "construction-related public investment"—a staggering sum. This vast outlay has undoubtedly produced engineering marvels: in 1998, for instance, Japan completed the Akashi Kaiky¯o Bridge, the longest suspension bridge in the world; just this year, the country began providing bullet-train service between Tokyo and the northern island of Hokkaido. The World Competitiveness Report ranks Japan's infrastructure as seventh-best in the world and its train infrastructure as the best. But while these trillions in spending may have kept some people working, no one can look at the Japanese numbers and conclude that the money has ramped up the growth rate. Moreover, the largesse is part of the reason that the nation now labors under a crushing public debt, worth 230 percent of GDP. Japan is less, not more, dynamic after its infrastructure bonanza.

Infrastructure spending is a form of investment: just as building a new factory can boost productivity, laying down a new highway or opening a new airport runway can, at least in principle, generate future economic returns. But the relevant question is: How do those future returns compare with the costs? Just because infrastructure is a form of capital doesn't mean that spending a lot on it is always smart. When a firm estimates the rate of return for a new factory, it can calculate the expected net profits and compare those with the expense. The analog for, say, new or improved roads is to estimate the benefits to users from reduced travel times, add the likely modest spillover benefits to nonusers, and then subtract the spending needed to construct and maintain the infrastructure. The results can differ significantly across projects. A well-known 1988 Congressional Budget Office survey found that spending to maintain current highways in good shape produces returns of 30 percent to 40 percent—but that new highway construction in rural areas showed a much lower return. A clever study that used firm inventories estimated that the rate of return to new highways was sizable during the 1970s but sank below 5 percent during the 1980s and 1990s.

Returns can vary substantially for other forms of infrastructure, too. One study found that adding a new runway to New York's hectic LaGuardia Airport would generate considerable value, but adding one to San Antonio's less frantic international airport would bring little benefit. Busy airports are likely to be worth improving; others, less busy, may not be. California's huge investment in high-speed rail was justified by a 2014 cost-benefit analysis that Parsons Brinckerhoff, the firm building the rail system, had prepared. The report predicted that total benefits from the project would range from $66 billion to $80 billion over several decades. That number looked reasonable when the projected price tag for the project was $35 billion, but the budget has already swollen to $68 billion—and is still expanding. In 2009, I calculated a rough cost-benefit calculation for a (fictional) high-speed rail link between Houston and Dallas and found that costs outweighed benefits by an order of magnitude. The returns to high-speed rail tend to be limited because air travel will still be faster and driving a lot cheaper. Outside the East Coast, meantime, train travelers would typically still have to rent a car once they arrived at their destination. President Obama's grand vision of "walking only a few steps to public transportation, and ending up just blocks from your destination" is at odds with reality in car-centered America. Has the president never been to Houston?

The existence of plausible transportation alternatives and the law of diminishing returns have also tended to reduce the benefits of infrastructure investment over the past two centuries. The opening of the Erie Canal in 1821 brought enormous value because the inland transportation options at the time were dismal. In the early nineteenth century, it cost as much to ship goods 30 miles over land as to send them across the entire Atlantic Ocean. Yet the very existence of canals, as much of a breakthrough as they represented, reduced the benefits of the later rail system, as Nobel economist Robert Fogel has shown. The returns for new transportation infrastructure in places with terrible roads, such as much of Africa and India, will be much higher than in the United States, which already enjoys an impressive, if under-maintained, array of mobility options.

What about the economic value of the shorter commuting times that new infrastructure can bring? Between 2009 and 2014, the Texas Transportation Institute estimates that the annual cost to Americans from traffic rose from $147 billion to $160 billion and that hours wasted in traffic increased from 6.3 billion hours to 6.9 billion hours, despite the surge in federal transportation funding. The time wasted has been particularly egregious in America's more successful metropolitan areas, like San Jose, where delays per auto commuter jumped from 56 hours in 2009 to

67 hours in 2014. Yet it's hard to see how substantially reducing time lost to traffic congestion will turbocharge the economy. Imagine that America gets its act together and cuts traffic time sufficiently to save $80 billion—a pretty miraculous improvement. That would still represent less than one-half of 1 percent of America's $18 trillion GDP.

Given such numbers, infrastructure advocates have downplayed standard cost-benefit analysis in favor of broad macroeconomic surveys, which look at the statistical link between public-infrastructure investment and overall economic activity. This method allegedly enables one to capture all the spillover economic effects of infrastructure. Standard cost-benefit analysis, these advocates say, misses the new businesses and jobs and ideas that will blossom because of the cheaper costs of transportation, as people move about and interact more freely.

Yet this macroeconomic approach can produce imprecise—and even wildly misleading—results. For example, if infrastructure gets built in anticipation of an expanding economy, the statistics will suggest that the new construction caused the expansion. A classic 1989 study by economist David Aschauer showed that postwar national growth rates improved after increases in public-sector capital-stock spending, but that hardly proves that infrastructure caused the growth. In 1990, Alicia Munell conducted a similar study for the Federal Reserve Bank of Boston focusing on state-level data. While these early studies showed high returns to infrastructure, later work has found the results quite fragile. High estimated returns often vanish when researchers control for common state trends or other economic variables.

I recently advised a Ph.D. student, Andrew Garin, studying the impact of the American Recovery and Reinvestment Act's highway spending on county-level employment. Garin's estimates show that highway projects had essentially zero effect on local employment, four years after the onset of the recession. The projects may have raised employment in the counties of the contractors—the statistical results are ambiguous—but he found no impact on the counties where the projects were built. The extra infrastructure, in other words, does not seem to have improved economic vitality anywhere that it might have been expected to.

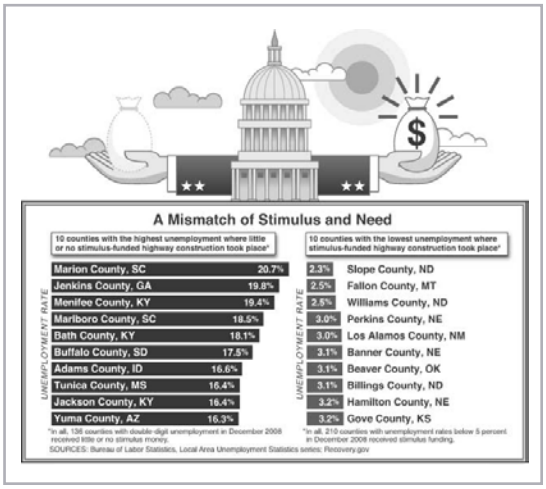
This isn't to say that new transportation infrastructure isn't valuable—I'd be thrilled to save an hour a week in commuting time. But that extra hour is unlikely to turn me into a vastly more creative and innovative person. Transportation infrastructure isn't a solution for America's lackluster growth rates.

Nor is transportation infrastructure a useful tool to fight joblessness during temporary economic downturns. The idea of using infrastructure building as a weapon against unemployment first entered American politics after the economic panic of 1893. Before that recession hit, in 1891, businessman and Ohio politician Jacob Coxey drafted his "Good Roads Bill." Coxey wanted the government to spend at least $20 million per month building roads across America, paying workers "at least 80 percent above the going hourly rate." This building campaign, he argued, would be financed by the printing press—Coxey was a pro-inflation Greenback Party member—and would hike government spending by 75 percent. Coxey is best remembered for the unorthodox manner in which he made his case in 1894: marching to Washington with hundreds of supporters. "Coxey's Army" failed to persuade Congress to support the Good Roads Bill, but its central idea remained in the air.

That idea received a major boost during the Great Depression. President Hoover's 1930 State of the Union address announced that, to fight the economic collapse and provide jobs, the federal government was "engaged upon the greatest program of waterway, harbor, flood control, public building, highway, and airway improvement in all our history." Hoover favored "still further temporary expansion of these activities in aid to unemployment during this winter." The distinguished Columbia economist John Maurice Clark praised Hoover's public-works promotion as a "great experiment in industrial statesmanship of a promising and novel sort."

Franklin Delano Roosevelt followed Hoover's lead on a much grander scale. The Civil Works Administration, the Public Works Administration, and the Works Progress Administration hired huge numbers of the unemployed and built infrastructure projects across the country. Roosevelt's friendship with New York City mayor Fiorello LaGuardia helped ensure that Gotham's infrastructure got a particularly impressive upgrade. The Lincoln Tunnel, LaGuardia Airport, and the Triborough Bridge—all were Public Works Administration projects. The nation's generally positive view of these ambitious undertakings helps sustain the view that Coxey was right: building infrastructure can put people to work and reduce the pain of a downturn.

Yet one should be wary of drawing infrastructure-related lessons from the 1930s for the twenty-first century. First, most of the U.S. had real infrastructure needs in the 1930s, so the risk that all those formerly unemployed people would be put to work on highly wasteful projects was relatively low. These days, the condi-



tions are sharply different. While a sensible anti-unemployment policy targets resources at areas that have high unemployment rates, many of those areas are today in long-term decline, and the last thing they need is new roads and bridges. For example, Detroit's infrastructure was built for 1.85 million people; now, after decades of difficulty, the city has less than half that population. New construction there makes no sense and would just squander money.

As it turns out, Recovery Act highway spending seems to have gone to low unemployment areas, as the chart on page 29 shows, which means that the funding was less likely to reduce joblessness and more likely just to shift workers away from other jobs. That's doubtless what has happened with the last of Massachusetts's recession-birthed mega-bridge projects, the ongoing Braga Bridge construction in Fall River. That town is unquestionably depressed, with a fearsome double-digit unemployment rate, but the project's contractor is based in Canton, Massachusetts—where unemployment is a healthily low 4.6 percent.

The relatively simple technology of infrastructure construction of the 1930s meant that the unskilled unemployed could easily be put to work building roads. Among the iconic images of the Great Depression are scores of men wielding shovels and picks. That isn't how roads and bridges are built anymore, though. Big infrastructure requires fancy equipment and skilled engineers, who aren't likely to be unemployed. The most at-risk Americans, if they're working at all, usually toil in fast-food restaurants, where the average worker makes $22,000 a year. They're typically not trained to labor on complex civil-construction projects. Subsidizing Big Mac consumption would be a more effective way to provide jobs for the temporarily unemployed than subsidizing airport renovation.

The building process was also much quicker in the past, meaning that projects proposed during the Depression could be started and even finished during the Depression, making them more likely to fight temporary joblessness. Robert Moses built the Triborough Bridge complex, the construction of which got under way on Black Friday in October 1929, in just four years. Such speed is hard to imagine today. Boston's Big Dig, to take one famous example, took 25 years from initial planning to its final completion in 2007. (See "Lessons of Boston's Big Dig," Autumn 2007.) Why have transportation projects become so much slower? Yes, they're usually more technologically complicated, but much of the time, politics is also to blame. As Alan Altshuler and David Luberoff chronicle in their masterful book Mega-Projects, earlier urban-infrastructure initiatives proceeded without worrying much about community opposition. To erect the Triborough, Moses could just demolish the buildings that he needed to get out of the way—neighborhood complaints be damned. Such tactics are no longer politically acceptable, so the Big Dig and other large-scale undertakings needed painstakingly to avoid inconveniencing anybody, dramatically raising costs and delays. New Deal projects also didn't face environmental-impact reviews, which can add years to a project timeline. Detroit's Gordie Howe International Bridge's review process took "four years of consultations, public hearings, traffic analyses, and environmental studies," to take a recent example. The project should be finished around 2020—15 years after that review process began.

This is not to dispute that transportation spending eventually creates jobs. But are they a good bargain? The ratio of Recovery Act transportation spending "outlayed or expended" ($33 billion) by 2012 to direct job-years created (113,347), as reported by contractor, is $295,000. Transportation spending also creates jobs indirectly, through the materials and machines used by the construction contractors; if we take those positions into account, the ratio falls to $114,000 per job-year created. These estimates may still be too high because each direct dollar of government spending leads to more consumer spending, as transportation workers buy new clothes and cars—but they may also be too low, since many of these workers, as we've seen, would have been employed anyway. The Council of Economic Advisers uses a number, based on prerecession studies, of $92,000 per job-year for all government spending.

To my eyes, even $92,000 per job-year seems too expensive. (The average worker in the U.S., it's worth noting, earns only about $40,000 annually.) Putting to work 10 million unemployed Americans in 2009 would have required $1 trillion in government spending per year. Cutting the payroll tax for poorer workers seems like a more efficient way to get firms to hire more people.

The third prominent infrastructure illusion is that transportation should be a centralized, tax-funded federal responsibility, rather than decentralized, user-fee-funded local responsibility. The most pressing problem with federal infrastructure spending is that it is hard to keep it from going to the wrong places. We seem to have spent more in the places that already had short commutes and less in the places with the most need. Federal transportation spending follows highway-apportionment formulas that have long favored places with lots of land but not so many people. For example, Alaska received $484 million in the 2015 highway-aid apportionment, which included support for metropolitan planning and air-quality improvement. This works out to about $657 for each Alaskan. Massachusetts received $586 billion, which amounts to roughly $87 per person. New York State received $1.62 billion, or $82 per person. Do these spending patterns reflect far greater transportation needs in Alaska than in New York City or Boston? No: the average commute time in Anchorage is 23 minutes, less than the national average, while the averages in Boston and New York are 30 minutes and 36 minutes, respectively.

Alaska's federal highway-aid haul is all too typical, unfortunately. Recovery Act transportation aid was twice as generous, on a per-capita basis,

to the ten least dense states than it was to the ten densest states, even though higher-density areas need more expensive infrastructure (retrofitting New York with tunnels and bridges, for example, is far costlier than building in the greenfields of the West). Low-density areas are remarkably well-endowed with senators per capita, of course, and they unsurprisingly get a disproportionate share of spending from any nationwide program. Redirecting tax dollars across jurisdictions is rarely fair—and it isn't right, either, that poorer, lower-density regions should subsidize New York's subway and airports.

Washington's involvement also distorts infrastructure planning by favoring pet projects. The Recovery Act set aside $8 billion for high-speed rail, for instance, despite the fact that such projects would never be appropriate for most of moderate-density America. California was lured down the high-speed hole with Washington support, but many voters now seem to regret that they took the bait. In a 2015 poll, 53 percent of respondents said that they would vote for "a ballot measure ending the High Speed Rail project and spending that money on water storage projects." Only 31 percent said that they would vote against that measure.

Idiosyncratic, foolish projects existed long before the Obama administration. Detroit's infamous People Mover Monorail would never have been built without federal aid. Alaska's $400 million Gravina Island bridge to nowhere was a particularly notorious example of how Congress abuses transportation investment. As the Office of Management and Budget noted, during the Bush years, highway funding was "not based on need or performance and has been heavily earmarked."

The Recovery Act largely left decisions about individual projects to the states, but it required them to move quickly. In some cases, this led to simple maintenance projects, like repaving, which usually make sense. But when it came to larger-scale investments, the push for speed ran the risk of poor planning. The Dulles Corridor Metrorail Project, the costs of which greatly exceed its potential benefits, seems unlikely to have moved ahead without the $900 million in federal assistance that it received in 2009.

Funding infrastructure with general tax revenues removes the discipline that comes when projects need to pay for themselves. If every new road or rail project had to fund itself, the projects that deliver the greatest benefits would be the ones that move ahead. If people are willing to pay to use infrastructure, we can assume that that infrastructure provides social value.

A user-fee approach is also fairer. With general tax financing, every American must pay for new highways in Montana, regardless of whether they drive or have ever been to Montana. It's much fairer for the people who use roads to pay for roads.

User-fee financing is even more attractive because it helps reduce congestion. Building more highways will never decongest America, for counterintuitive behavioral reasons. Economists Gilles Duranton and Matthew Turner have empirically identified the Fundamental Law of Road Congestion, which is that highway miles traveled increase roughly one-for-one with highway miles built. If we build it, people will drive it. The correct fix for crowded roads is to charge people for the social costs of their choices. Singapore instituted congestion pricing in 1975, and now operates state-of-the-art electronic road pricing, with tolls that vary by usage and time of day. London has now had congestion pricing for a decade. Both cities have eased traffic as a result. Yet America still acts as if charging drivers is a crime. For decades, federal rules prevented the levying of tolls on interstate highways. The Obama administration deserves credit for supporting the possibility of tolling the system.

The federal role in transportation should be limited to certain key tasks. Washington can certainly help coordinate local investments to improve the functioning of a national transport network, as it did when building the Eisenhower Interstate Highway System. The federal government should maintain safety and maintenance standards, on the road and in the air, and can nudge localities to maintain their infrastructure. Finally, it can encourage transportation, especially buses, that helps the poor find jobs. But none of this requires a massive national spending spree.

Many tasks of government have nothing in common with private enterprise. Neither our military nor our courts should be in the business of extracting revenues from, respectively, foreign powers or litigants. Aid to the poor and to the elderly is meant to be money-losing. But infrastructure is different and has much more in common with ordinary businesses. After all, infrastructure provides valuable services, the use of which by one individual typically crowds out the use by someone else. E-ZPass technology has made it simple to charge for transportation. Why not, then, establish a business model for transportation infrastructure?

The upsides would be substantial. When businesses running, say, a public road need to recoup their costs over years and decades, they have a strong incentive to maintain the infrastructure properly. A transportation business model also avoids the messy redistribution of the current system, where some states subsidize others and non-travelers subsidize the mobile. In some cases, the business model for transportation might be completely private. The Route 91 Express Lanes are private roads built within the median of California's Riverside Freeway. For 20 years, they have charged varying tolls based on time of day, and drivers have proved willing to pay. The Orchard Pond Parkway in Florida is another private road. Private airports operate in America and across the globe, and, in many cases, such private infrastructure has performed extremely well. Clifford Winston, a distinguished transportation economist, has argued for the privatization of all of America's high-

ways. That would be a difficult task, however. While drivers usually accept tolls for new roads, they hate tolls slapped on to previously free roads. Consequently, it's easier politically to fund new projects with user fees than to impose them on older infrastructure. Any new project thus should come with a user charge, right from the start.

Private ownership isn't the only sensible model for transportation. Private control raises the specter of monopolistic pricing that harms consumers, though this can be addressed with reasonable regulation. Or, if transportation still needs government funding—perhaps because we want a subway system to reduce congestion on unpriced streets or because we want buses to provide cheap mobility for the poor—private operators might pressure the government to increase their subsidies excessively. Americans may feel more comfortable if many projects remain in public hands.

When we can't go private, another plausible option is an independent, but public, entity. In some cases, independent public entities have worked well, putting the focus on service rather than on politics. Robert Moses's Triborough Bridge Authority maintained both its bridges and its first-class credit rating for decades, despite the turbulence of New York politics. Many of America's airports are well run, despite public ownership. But taking this path requires intensely focused management. Few mayors or governors can run an airport on top of their day jobs. New York's notoriously corrupt and inefficient Port Authority provides a telling example of what can go wrong with this model. (See "Let's Break Up the Port Authority.")

A shift to an expanded role for the private sector in infrastructure construction and maintenance thus seems like a good bet. And America is not short on private-sector transportation innovators. Our cars are more technologically impressive than ever. American freight rail is a wonder of the world. Cheap bus services ride up and down I-95. Uber and Zipcar have upgraded urban mobility for the Internet age. The parts of the transportation system competitively produced by the private sector are in great shape; the parts folded within the public sector are often, though not always, an embarrassment.

Economics teaches two basic truths: people make wise choices when they are forced to weigh benefits against costs; and competition produces good results. Large-scale federal involvement in transportation means that the people who benefit aren't the people who pay the costs. The result is too many white-elephant projects and too little innovation and maintenance.

No one denies that the United States suffers gaping infrastructure deficiencies, including potholed roads, unsafe bridges, and awful airports. But we also have a dreary history of federally supported infrastructure boondoggles. America spends too much time arguing about whether to spend more money or less on infrastructure—including as a jobs program—and far too little time on how to construct and maintain infrastructure wisely. Treating transportation infrastructure as yet another public-works program ensures the mediocrity that we see all around us. A wise approach means, contrary to Bernie Sanders, a much diminished federal role and a lot more transportation initiatives that look like private industry, with users paying for the services they receive.

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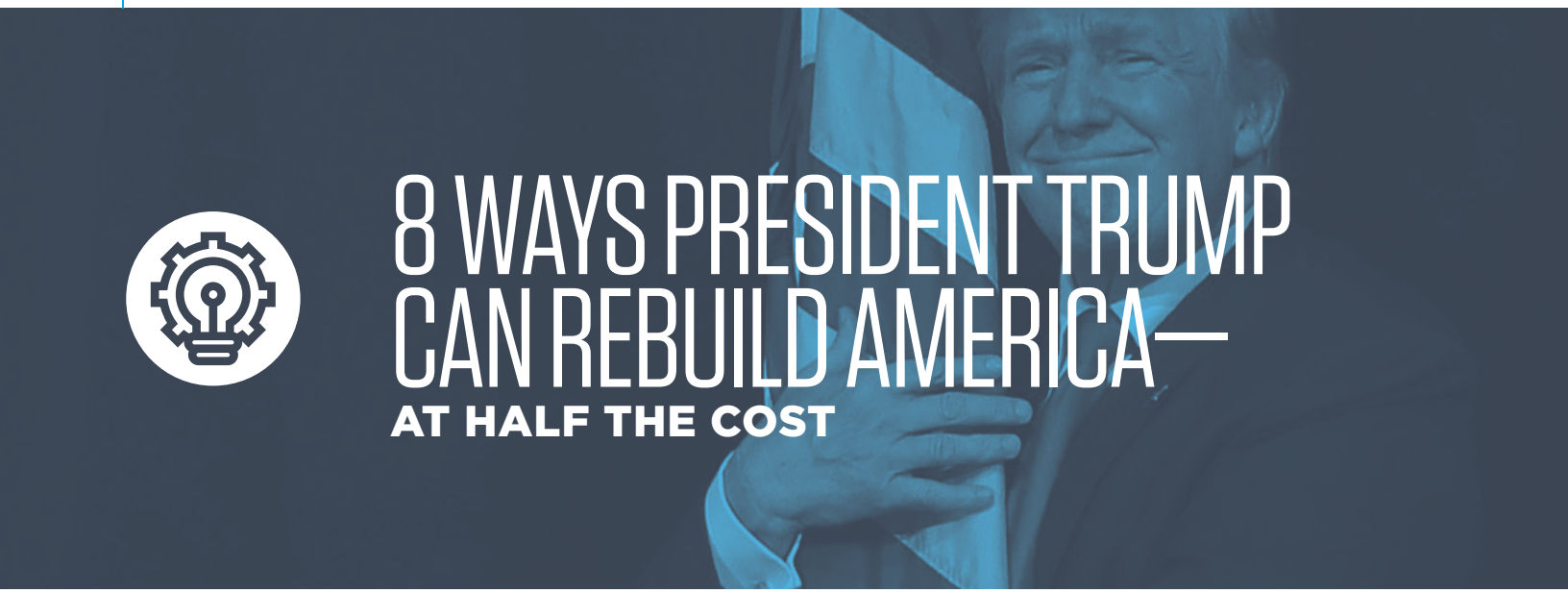

8 WAYS PRESIDENT TRUMP CAN REBUILD AMERICA—
AT HALF THE COST

NICOLE GELINAS

In his inaugural speech Friday, President Trump promised "a great national effort to rebuild our country." To that end, he has already floated a plan to spend $550 billion over four years on infrastructure. And when it comes to spending on roads, transit and airports, nobody in Congress is in favor of small government. That was obvious during the confirmation hearing this month for Trump's nominee for transportation secretary, Elaine Chao.

A parade of senators asked for everything from new highways through "treacherous terrain" in the Southwest to commuter rail in New Hampshire. "How are we going to pay for all these great ideas?" Chao asked rhetorically, as senator after senator asked her to support each state's pet project. (And no one was curious about cutting costs.) But we can get a lot of good infrastructure for less than $550 billion. Even spending half that would give us a great start. And how to pay is easy: Washington borrows money for solid long-term investments, just like everyone does. The harder part is to make sure they are good investments. Here are eight good ideas for America's infrastructure:

1 | BUILD A RAIL TUNNEL UNDE THE HUDSON RIVER BETWEEN NEW YORK AND NEW JERSEY

2 | HAVE A COMPETITION, TOO, FOR BETTER COMMUTER RAIL

3 | FINISH THE SECOND AVENUE SUBWAY

4 | LAUNCH A COMPETITION FOR TRAIN-TO-THE-PLANE PROJECTS

5 | BUILD AN INTERSTATE HIGHWAY BETWEEN LAS VEGAS AND PHOENIX

6 | FIX THE NATION'S SUBWAY SYSTEMS AND COMMUTER RAILS

7 | THE WALL

8 | HELP STATES, CITIES AND TOWNS DO BASIC MAINTENANCE AND MANAGEMENT

1 BUILD A RAIL TUNNEL UNDER THE HUDSON RIVER BETWEEN NEW YORK AND NEW JERSEY

The existing tunnel is 107 years old. It's falling apart faster now because of damage from Hurricane Sandy nearly five years ago. But Amtrak can't shut it down without disrupting rides for 200,000 people daily, most of them New Jersey Transit commuters from New Jersey to New York.

As New Jersey Sen. Cory Booker said at Chao's hearing, "more people use those tunnels than the entire population of South Dakota every day... If these tunnels would go down, they would cost about $100 million in lost productivity every single day."

Already, commuters are suffering more unpredictability — and lost productivity at work and at home — as Amtrak scrambles to keep up with the deterioration to tracks, signals and electrical wires.

A new tunnel would make life better for Jersey residents and their New York employers and colleagues. But it's an even bigger interstate project than that. More capacity would mean that Amtrak could offer more service from Washington through New York to Boston, part of a plan eventually to cut travel times among the three cities.

Crucially, too, the tunnel is a project that nobody objects to. For that reason, it's a better prospect than New York and New Jersey's other mega-project: a new bus terminal for the commuters who take buses instead of trains. Yes, the Port Authority Bus Terminal is falling apart, too, with its upper floors unable to bear the weight of today's bigger buses.

But the reality is New York and New Jersey politicians have no clue how and where to build a new bus terminal without hurting the people who live and work in Hell's Kitchen and without disrupting existing commutes. The two states still need years to show they can take these problems seriously, not money now.

Cost: $20 billion for the tunnel

2 HAVE A COMPETITION, TOO, FOR BETTER COMMUTER RAIL

From Silicon Valley to Massachusetts,

highways are getting more crowded at rush hour, yet almost nobody takes the train to work. As rookie New Hampshire Sen. Maggie Hassan said at Chao's hearing, even her once-rural state could use commuter-rail investments into Boston as the immediate suburbs become more crowded and expensive.

Let's have a national contest for new commuter-rail line cash for regions willing to build denser housing — condos, apartments and single houses closer together — around those lines.

More commuter rail would take some pressure off high-cost cities, too, as people would have more housing options outside of the metropolises.

Cost: $50 billion

3 FINISH THE SECOND AVENUE SUBWAY

New York is finally enjoying the

first three stops of the subway, with the first of what will eventually be 200,000 new riders experiencing a faster commute and more time with colleagues or with family (depending on whom you like better). But the subway is supposed to go up through Harlem and, in the other direction, downtown. The state and city haven't started work, or found most of the money, for the next three stops.

Cost: $8 billion

4 LAUNCH A COMPETITION FOR TRAIN-TO-THE-PLANE PROJECTS

Only in America can you not take a train from urban centers to the plane — or, at least, do it in under two hours. Gov. Andrew Cuomo wants to build train connections to both JFK and La Guardia but hasn't said how he'll pay for them. Boston, too, has a primitive bus system to get you to your plane, and Chicago has only a subway that makes local stops. Getting more businesspeople and tourists on high-quality trains from city centers to airports means less traffic on local roads and highways.

Cost: $15 billion

5 BUILD AN INTERSTATE HIGHWAY BETWEEN LAS VEGAS AND PHOENIX

As new Nevada Sen. Catherine Cortez Masto, who ran partly on the issue, said at the hearing, these cities "are two of the largest in the country"—just 300 miles apart—"that are not connected by an interstate." Fixing this would be good for tourism and business and good for public safety, too, as highway travel is much safer than travel on smaller roads.

It would be a good idea, too, to study the idea of building rail along the new interstate, to give people a free-market choice of how to travel. That way, people going from outlying areas of each city could drive, but people going from Phoenix's increasingly popular downtown to visit Las Vegas wouldn't need a car for the trip, just like from New York to Boston.

Cost: $10 billion, more with rail

6 FIX THE NATION'S SUBWAY SYSTEMS AND COMMUTER RAILS

It's a good thing it doesn't snow any-

more, because Boston's subways barely work in a blizzard. Even on a good day, the Red Line, which was once a dream compared to New York's packed trains, is a disaster of delays and breakdowns. San Francisco passengers, too, are suffering the effects of years' worth of delayed maintenance.

To ride the DC Metro is to take your life in your hands; nine commuters and nine workers have died in little more than a decade. New York is in better shape but could use more money for normal repair and replacement and for modern signal technology to run more trains closer together, as well. Commuter rails around the country, including in New York, could still benefit from converting rails to electric — a rather proven technology by now — from diesel.

Money, though, should come only with much better accountability for exactly how it is spent and on the results. The feds should compare who does this work most efficiently and reward them over a period of time with more.

Cost: $50 billion

7 THE WALL

Relax, please, if you hate the Wall.

And (if you don't like Trump) stop falling into the trap that helped Trump win. Many Trump voters were sophisticated enough to understand that border security is core national infrastructure.

There is a reason why the US government makes you put your passport in the little slot at JFK when you come home from skiing, before they let you pass through what is, well, the immigration hall's physical wall: It is generally thought to be a good idea to have some dim notion of who is coming and going.

Border crossings from Mexico and points south are down from a decade ago, in part because of bipartisan efforts and more than $100 billion worth of spending to make it harder. In fact, we already have big chunks of a wall on the Mexican border (really — I saw it!).

But with nearly 200,000 people still making the trek each year, we still face both a security risk and a humanitarian risk.

For all of Trump's bluster, his proposal is to keep doing what we've been doing and do it better: using physical barriers as well as technology to make it even harder (Trump's voters

were also smart enough to realize that a wall can be partly metaphysical). A securer border is good for workers, too: People who have no right to work in this country are the easiest to exploit and endanger, and employers use their presence to push wages down for other low-wage workers.

Cost: At least $20 billion. (And yes, Mexico can pay for at least part. The US government can tax the money that workers here send back home to Mexico. This idea may be good or bad, but it is not, and never was, absurd, as Trump's opponents often claimed.)

8 HELP STATES, CITIES AND TOWNS DO BASIC MAINTENANCE AND MANAGEMENT

As we know from Flint, Mich., some states and cities don't even have the financial resources or competence to guarantee the basic right of safe water. Closer to home, Syracuse, too, has long requested money for water investment.

Poorer areas are in a vicious circle: If you can't deliver water, keep the streetlights on and fill in potholes, you'll lose even more residents. The feds should offer grants and zero-interest loans for particularly distressed areas, coupled with outside management expertise to help them relearn the basics.

For middle-class and wealthier areas, the feds could offer smaller grants and slightly higher interest-rate loans to do the basic work of filling in the cracks in the roads. Some of these boring but vital projects are expensive, too: New York will need close to $2 billion to keep the Brooklyn-Queens Expressway from falling down.

Cost: $50 billion

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TRUMP NEEDS TO THINK BIG AND BUILD RIGHT TO REFORM OUR INFRASTRUCTURE

NICOLE GELINAS

Donald J. Trump became president-elect in part because people are fed up with government incompetence. One place where that's obvious is infrastructure. Comparing us to China during the campaign, Trump said: "they have railroads and trains that go 250 miles an hour. We have the Long Island Rail Road that chugs out to Long Island and chug, chug chug."

Now Trump wants to spend a trillion dollars to fix the problem. That's 40 percent higher than our existing spending. It's easier to spend a trillion dollars poorly on trains, bridges, and water than it is to spend it well.

Four tips for Trump on how to succeed in infrastructure beyond ice rinks:

1 | THINK BIG

2 | DON'T WORRY ABOUT BORROWING MONEY

3 | MAKE DEALS

4 | QUALITY IS MORE IMPORTANT THAN SPEED

1 THINK BIG

Think Big. Yes, we have to fix our existing infrastructure. We need a replacement tunnel under the Hudson River because the old one is deteriorated. But we should build new things, too. Why shouldn't we have real high-speed rail service between Washington and Boston, cutting an hour off of each trip?

2 DON'T WORRY ABOUT BORROWING MONEY

Trump says his infrastructure plan will be "deficit-neutral": he'll either raise new taxes to cover the spending, or force projects to pay for themselves.

But it's more important to differentiate between infrastructure projects that can pay for themselves, and infrastructure projects that can't. Airports, big bridges, and pipelines can pay for themselves through customers' fees and tolls.

Subway and commuter-rail projects can't — but they are still worthy.

3 MAKE DEALS

Make deals. Most infrastructure spending is at the state and city level. The feds provide about a quarter of the money, but don't have much control. Trump should help states and cities spend smarter by rewarding those who plan projects well, finishing on time or on budget.

Federal, state and local governments should consider environmental and other impacts of projects, but they shouldn't delay for years.

Trump should prioritize projects where construction workers and managers have agreed to reasonable work rules and staffing levels, so that they don't waste taxpayer money.

Trump mentioned the Long Island Rail Road. But one reason the railroad has been so slow to build a new station on Manhattan's East Side is because workers could never agree who would do what work, causing delays.

4 QUALITY IS MORE IMPORTANT THAN SPEED

Quality is more important than speed. The point of infrastructure projects is to build better infrastructure — not to create jobs or cut ribbons fast. Spending too much too fast is a risk. Pushing too hard too fast drives costs up, as managers scramble to find skilled workers and materials.

Trump should focus on what to build, and how, rather than stick to an artificial timeline and dollar amount.

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FOR INFRASTRUCTURE, SPEND SENSIBLY TO MAKE A DIFFERENCE, AND AVOID MISTAKES

NICOLE GELINAS

Pick a few marquee projects to make models for others, and small projects for quick results. Don't overpay workers but don't look for profits.

President-elect Donald J. Trump said in his victory speech that "we are going to ... rebuild our highways, bridges, tunnels, airports, schools, hospitals. We're going to rebuild our infrastructure." He had already announced a plan to spend $1 trillion over 10 years. But if he's not careful, he'll be using it to pay for critical mistakes.

Back in 2009, newly elected President Obama deliberately kept his own stimulus plan to $832 billion, including $50 billion for infrastructure, partly to avoid the backlash from fiscal conservatives on breaking the 13-figure mark.

Trump is saying he wants to create "thousands of new jobs." Obama was more cautious at a time when the country was in the midst of hemorrhaging nearly 9 million jobs, unemployment would top 10 percent that fall.

Though recovery has been slow, we've regained all our lost jobs and then some. Unemployment is now at 4.6 percent. It is a mark of deep change that a Republican presidential candidate could have bragged about such a trillion-dollar spending plan at such a time.

But consider: Last December, Obama signed a transportation-infrastructure bill to spend $305 billion over five years, or $61 billion a year. Spread out over 10 years, Trump's trillion dollars would increase spending by just $39 billion a year. That $39 billion would be spread over 50 states, many of which already have tens of billions of dollars in infrastructure backlogs after a near-decade of infrastructure austerity.

CONTINUED ON NEXT PAGE

1 | HOW CAN TRUMP MAKE SURE TAXPAYER MONEY GOES FAR?

Trump's surrogates have also mentioned spending on commercial projects like shipyards and pipelines. Making those kinds of investments with taxpayer money would reduce the effect the trillion dollars would have on public infrastructure.

And while helping states catch up with regular road maintenance is a good thing, it would put Trump in the same position Obama faced after his own stimulus: voters perceived little change after a supposedly historic investment.

1 HOW CAN TRUMP MAKE SURE TAXPAYER MONEY GOES FAR?

Focus on the projects, not jobs. The fact that infrastructure investment creates jobs is a good thing, but that is not the purpose of the investment. Workers should be paid well, but paying them too well -- a New York City construction worker can make $79.63 an hour, including benefits -- means building less.

Pick out a few projects of national importance and create a commission that, in say, three months, could figure out how to cut red tape and speed their completion. One marquee project could be a new tunnel under the Hudson River, as part of higher-speed rail service on the northeast corridor. States and regions could compete for consideration of these multibillion-dollar projects.

Don't focus on profits. Trump mentioned bridges, tunnels and airports in his speech – all of which can generally pay for themselves. In New York, Gov. Andrew Cuomo's LaGuardia airport rebuilding project will be funded, indirectly, by airline passenger fees. New York's bridges and tunnels collectively throw off hundreds of millions in dollars in profit a year, money that goes to subsidize mass transit. Likewise, pipeline, electricity and water projects can usually pay for themselves. Washington should pay for projects that can't pay for themselves, including transit projects in some of the densest areas of the country, and in parts of the country whose residents would like to become denser.

Help state and local governments—which get most federal infrastructure money—spend their money more wisely. Over and over, they have proven that they cannot keep projects on time or on budget: consider the Big Dig in Boston, or the seismic retrofitting of the Bay Bridge in San Francisco. The Trump administration should create a national clearinghouse, with transparent reports from federal auditors, so that states and cities can learn from each other what goes right on projects, and what doesn't. State and local governments that can sign labor agreements that improve productivity and that can design management structures to deliver projects efficiently should be rewarded with bonus funding for future projects.

Don't be afraid to think small. Small federal grants—in the millions or tens of millions of dollars each—can help states, cities and towns start or improve bus service, build sidewalks and bike lanes, and otherwise give people more choices on how to get around in addition to the automobile. Such investments are good for poorer people, who must spend more of their money, as a percentage of income, on transportation.

Smaller projects have another benefit, as well: Trump is up for re-election in four years, and people will want to see quick results.

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REBUILDING AMERICAN INFRASTRUCTURE

AARON M. RENN

When Donald Trump chose "Make America Great Again" as his campaign slogan, he put words to something Americans had increasingly come to see and feel. For many people, their personal lives and communities were no longer as great as they used to be, and they were looking for someone to set things right. Restoring rather than building greatness is an unusual challenge in America. But it is one that has become increasingly real over the last two decades, as much of the country has sunk into a malaise that is physically visible in distressed but once-thriving towns.

This need to Make America Great Again applies especially to our infrastructure. We have already built fantastic national networks of highways and bridges, airports, rail lines, inland waterways, electricity, water and sewer, and telecom infrastructure. The challenge today is not to build some vast footprint of new infrastructure in the style of the Transcontinental Railroad. Rather, it is to make the infrastructure we already have, much of which has been unconscionably left to decay, great again.

Like the project of restoring prosperity to many of our communities, this is an unusual challenge in our national history—and a politically difficult one, too. Politicians love to cut ribbons on new projects; it is much less exciting to maintain and renovate something built long ago under previous administrations. That political incentive to favor new construction over maintenance is part of how we got into this situation.

But this is a task President Trump knows something about. He has already proven that he knows how to obtain glory from rebuilding, not just building, infrastructure. In the 1980s, he pulled off a public relations coup by rescuing the reconstruction of Wollman Rink in Central Park.[1] This meant rebuilding an ice rink that already existed, not creating an ice rink in the first place. But Trump still became a hero from it. This ability to make rebuilding buzzworthy means President Trump is the right man to make America's infrastructure great again, if he focuses the government's efforts on the right challenges and approaches.

CONTINUED ON NEXT PAGE

1 NEW INFRASTRUCTURE IS NOT A PRIORITY

Too often the term "infrastructure" is conflated with "transportation," especially highways. This is because the federal government is a major financier of highway and transit infrastructure, and debates over the federal highway bill, the gas tax, etc., generate significant debate and publicity.

But America's infrastructure encapsulates much more than just roads, even if the federal government is less directly involved in funding it. For example, there is the electricity infrastructure, which provides nearly ubiquitous power to the nation. Most of this infrastructure is privately owned by utility companies, and so receives less debate in Washington.

A look at our electric infrastructure helps illustrate the nature of today's infrastructure needs. The initial electrification of the country provided enormous benefits to which it is difficult for us to relate. How many of us can imagine what life without electricity was like? This process of electrifying America was largely carried out by private utilities. The federal government helped by extending electricity to underdeveloped and hard-to-serve rural areas through programs like the Rural Electrification Administration and the Tennessee Valley Authority.

There is no way for us to replicate the gains that came from electrifying the nation, since basically everybody who wants electricity already has it. Today's expansions are limited, mostly to serve new development. The need today is to repair or replace aging transmission lines, substations, and power generation plants, updating them to twenty-first-century needs. Much is made of the so-called smart grid or smart meters, but it is difficult to see these as economic game-changers for America. Their value is also questionable to the average person, as they come with serious privacy concerns and security risks.

It is similar with water and sewer lines. America is already well served either by utilities or by high-quality well and septic systems. How many people today don't have running water and flush toilets in their homes? Again, these were revolutionary at the time, but those gains can't be repeated. The main challenge is to rebuild aging systems and bring them up to modern standards, though some areas do need to develop additional water sources.

The same applies to transportation. When the Erie Canal was completed in 1825, it offered revolutionary increases in travel speeds. Compared to the horse and wagon, the canal cut travel costs between Buffalo and New York City by 95 percent.[2] Other transport innovations like the railroad, the automobile, and the airplane also radically increased travel speeds and reduced transport costs.

Previous generations already built out networks for our major transport modes, and there are no game-changers in speed improvements on the horizon. David Metz, former chief scientist of the UK Department of Transport, argues, "We have largely run out of possibilities for travelling faster by means of new technologies."[3]

The one transportation technology the United States has not employed is high-speed rail. But even in Europe this is a niche service. It also is not faster than flying in most cases. Projects like Elon Musk's "hyperloop," which uses tubes to transport people or freight between cities at extremely high speeds, are speculative at best.

One area where new infrastructure needs have emerged recently is in telecommunications. The nation's wireline network was deployed decades ago, and the internet created a need for a vast new broadband network. However, the marketplace has largely taken care of this problem. Most of America, outside of some rural areas, already has high-speed access, and there's an enormous high-capacity backbone network in place. Private companies likewise continue to invest in ever-better wireless data networks. There appears to be little need for government intervention here, outside of subsidizing service to the poor or difficult-to-serve regions.

In short, our infrastructure systems are, by and large, built out. There is little need for a major deployment of new infrastructure, or new types of infrastructure. There do not appear to be any huge economic gains to be had from new infrastructure on par with those coming from electrification or building the interstate highway system. That is not to say that we do not need to build any new infrastructure, but additions such as new pipelines will be incremental, not revolutionary.

2 INFRASTRUCTURE INVESTMENT IS NOT AN ECONOMIC DEVELOPMENT TOOL

Those who advocate increased infrastructure spending often tout it as an economic development tool. However, as just shown, there is little in the way of cost reduction or other game-changing economic benefit left to be had from new infrastructure development because America is already largely well served.

One area where new infrastructure investment can potentially enable economic growth is by opening new land to development, converting rural land into urban land. This is pejoratively labeled "sprawl" by opponents. But in rapidly growing areas like Dallas-Fort Worth or Houston, expanding the urban footprint to accommodate demand is clearly needed. Regions like the San Francisco Bay Area that have failed to expand their urban

footprint in response to demand have seen housing prices soar into the stratosphere. The same need for expansion to serve rising demand might also apply in the case of new transport lines, such as the Second Avenue Subway in New York, whose completion is badly needed to relieve overcrowding on other lines.

But adding new water lines and expanding roads to keep pace with growth is not what most people mean by economic development. Instead, they view infrastructure expansion as a way to stimulate development in slow-growing or struggling areas. This is where the trouble begins.

First, it is here that the sprawl critique holds more water. New construction on the fringes of a region that is not growing will only devalue development elsewhere. The location of development may be influenced, but not the overall sum of regional development. This is just robbing Peter to pay Paul. For example, between 1980 and 2011, governments in the Buffalo, New York, area issued almost 60,000 building permits for single-family homes—while the region lost population.[4] Subsidizing infrastructure to serve this kind of development makes no sense. America does too much of this.

Also, as Harvard economist and Manhattan Institute senior fellow Ed Glaeser has pointed out, a signature attribute of a shrinking city or region is excess infrastructure—too many houses, streets, sewer lines, etc.—relative to its reduced population and commercial base. Building new infrastructure only adds to this pile of woes. The paradigmatic example is the forlorn Detroit People Mover monorail that circles its downtown. I75 near Flint, Michigan, is already eight lanes wide. Many impoverished, aging, or shrinking rural areas are now crisscrossed by four-lane highways, to little economic effect. There may be an equity case to be made for serving these areas, but not an economic one.

Even in relatively successful regions, new infrastructure often does not pan out the way boosters had hoped. For example, Google chose the Kansas City region in a nationwide competition to become the first market for its new Google Fiber service. Google laid a super-high-capacity network with direct fiber service to homes, a service that debuted to much fanfare locally and nationally. But a recent Bloomberg review of the project found that, despite local backers' initial claims that this was a "once-in-a-lifetime opportunity" to "spark economic development," results were poor. Kansas City has not become a major tech hub, and its GDP growth has trailed the nation since the fiber system went live.[5]

Unsurprisingly, Google has halted the rollout of Google Fiber into additional markets beyond the cities where it already operates.6 Here, Google follows on the heels of Verizon, which largely halted the rollout of its own FiOS project in 2010.[7]

Those who believe that a new piece of infrastructure will have similar economic effects to the Erie Canal seem doomed to be disappointed. Any economic gains from new infrastructure will be incremental at best.

3 AMERICA'S INFRASTRUCTURE IS IN NEED OF REPAIR

The American Society of Civil Engineers (ASCE) publishes an annual "Infrastructure Report Card" for the United States. Its 2017 edition gives the country an overall D+ score for infrastructure.[8] Roads, aviation, and drinking water all get a D, among many bad grades across all dimensions of infrastructure. But ASCE members stand to gain a lot of work from any major infrastructure program, so they've got an incentive to play up the problem. Their take should be crosschecked against other sources.

In truth, the condition of some of America's infrastructure is often not as bad as generally perceived or portrayed. According to the Federal Highway Administration, there are 59,000 structurally deficient bridges in the United States. That's a big number, but it amounts to only 9.6 percent of total bridges in the country.[9] High-profile infrastructure failures are also not always caused by a lack of maintenance. The I-35W bridge collapse in Minneapolis, for example, appears to have stemmed in large part from a design flaw.[10] According to an analysis by the Reason Foundation, only 5.4 percent of urban interstates are in poor shape.[11] The transportation research organization TRIP gives a higher estimate, saying that 20 percent of the nation's major roads are in poor condition—32 percent in urban areas.[12] For highways and bridges alone, only a minority, perhaps a fairly small minority, of major facilities is actually in poor shape. (Local streets often are in poor shape, but as we'll see, these are not eligible for federal grants.)

America's freight rail system is also in solid shape. Even the ASCE gave it a grade of B, noting the major investments by the system's private owners—$27.1 billion in 2015 alone.[13]

Anyone who has flown through a dazzling foreign airport like Madrid Barajas can tell you that American airports do not measure up. Even so, it's important to acknowledge that many American regions have spent heavily to improve their air travel facilities. Chicago spent about $10 billion on its O'Hare Modernization Program to add and reconfigure runways at this critical hub.[14] Indianapolis and Detroit replaced their decrepit terminals with sparkling new facilities. Even LaGuardia Airport's notorious Central Terminal, the one that regularly causes American politicians such as former vice president Joe Biden to compare our airports to Third World countries, is now being replaced at a cost of $4 billion.[15] America's air infrastructure may have a way to go, but progress has been made. And as anyone who has flown to London can tell you, America has no monopoly on bad airports.

Also, it is not necessarily a bad thing to have a certain percentage of our infrastructure at or near end of life. After all, few of us maintain all of our personal infrastructure and possessions at pristine levels of quality. How many people replace their furnace at the first sign of rust, rather than waiting until it is truly at end of life and can no longer be cost-effectively maintained? American citizens and businesses very frequently "sweat the assets" when it comes to their own property, so it should not be surprising that they are often less than impressed with calls to spend more tax dollars on infrastructure.

Yet there clearly are major infrastructure repair needs in America. We have not been properly maintaining the assets we have built. Levee failures notoriously caused much of the flooding in New Orleans after Hurricane Katrina, but America has yet to address the neglect of its dam and levee systems. For example, the recent possibility of an overflow or collapse at the Oroville Dam in California forced 180,000 people to be evacuated.[16] Many dams, levees, and locks on our inland waterway system are in need of repair, often at significant cost. Examples include Locks 52 and 53 on the Ohio River. Built in 1929, their replacement cost is $2.9 billion. As the New York Times reported, this replacement has been botched, and it was originally supposed to cost only $775 million—still a lot of money.[17]

Tens of billions of dollars are also needed simply to renovate America's legacy transit infrastructure. The District of Columbia's own Metro subway system has suffered several accidents that require emergency repairs to improve safety. It lost 14 percent of its riders last year, as they lost faith in the system.[18] San Francisco's BART rail system needs at least $10 billion in repairs.[19] Boston's transit system needs over $7 billion in repairs.[20] New York's subway signals still mostly rely on 1930s-era technology.

Similar maintenance backlogs affect other infrastructure types. America's older urban regions need to spend vast sums of money on sewer system environmental retrofit—$2.7 billion in Cleveland and $4.7 billion in Saint Louis.[21] The state of Rhode Island had to pay $163 million to replace its Sakonnet River Bridge because it had failed to perform routine maintenance on the old one.[22] This is just a sampling of America's infrastructure gaps.

But the poster child for American infrastructure problems is Flint, Michigan, where a water treatment error caused lead to leach into the water supply, rendering it unfit for human consumption. This caused then-candidate Trump to say, "It used to be cars were made in Flint, and you couldn't drink the water in Mexico. Now, the cars are made in Mexico and you can't drink the water in Flint." To be clear, Flint's water crisis was caused by human error, but that was only possible because of the city's old lead-pipe infrastructure. America's water lines, in many cases, haven't been touched since they were originally installed many decades ago. Some cities still have wooden water pipes in service. Syracuse mayor Stephanie Miner once said that if her city received the same $1 billion commitment from the state that Buffalo did, she would spend three quarters of it just to fix the city's water lines.[23]

While things are not uniformly dire, it is clear that there is a need to repair and upgrade America's existing infrastructure. It is this rebuilding, not building—making America's infrastructure great again—that the Trump administration should focus on.

In doing this, however, President Trump faces several major barriers that must be addressed before progress can be made. Politics and regulations will remain a barrier even if more funding is put in place. The existing federal infrastructure finance programs are poorly aligned with America's needs in any case, and private funding is at best a partial solution in many troubled infrastructure categories.

4 BARRIERS TO IMPROVEMENT: POLITICS AND REGULATION

Many of the biggest barriers to fixing America's infrastructure are not financial, but political and regulatory. Take, for example, the sorry state of the New York region's airports. How is it possible that one of America's wealthiest regions has such poor airport terminals? The problem is politics. The three main New York airports—Kennedy, Newark, and LaGuardia—are run by the bi-state Port Authority of New York and New Jersey. These airports are highly profitable, generating $581 million in operating profits in 2016 alone.[24] But the Port Authority uses those profits to subsidize the money-losing PATH subway and real estate developments like the World Trade Center. This tangled web of cross-subsidies, and the politics of New York and New Jersey that make them difficult to unwind, are why the airport facilities are in such bad shape. When New York governor Andrew Cuomo made a political priority of replacing LaGuardia's Central Terminal, a deal was quickly struck for its replacement. Airport improvements are also often opposed by the airlines themselves, who do not want to pay the increased fees needed to finance them.

Many pieces of infrastructure paid for through utility fees—electricity, water, sewer, etc.—also face political challenges to upgrades. Many of these services are de facto monopolies and thus subject to rate regulation. Politicians have a powerful political incentive to keep rates low, at the price of deferring maintenance and other needed investments. This is especially true for municipally operated water and sewer systems. For privately run utilities like electricity, capital investment has historically been strongly opposed by organized citizen groups that exist to maintain

low rates. In some states, the opposite has occurred. Utility interests have captured the regulatory apparatus, resulting in poor oversight and sometimes dubious investment that does not serve the public interest, such as the Deepwater Wind offshore wind project in Rhode Island that will cost consumers hundreds of millions of dollars.[25]

Activist pressure of other sorts can also derail projects subject to approval by weak-kneed politicians. In recent years, perhaps the most famous examples are President Obama's rejection of the KeystoneXL and Dakota Access pipelines. Environmental activists regularly attempt to kill infrastructure associated with fossil fuels. This often works in places with amenable governments.

Environmental studies are another major killer, driven by both federal and state laws. No one wants to go back to the days in which projects could be built with no review, when workers regularly died on work sites, and so on. But today's process of creating environmental impact statements (EISs) frequently drags on for years, leading to delays of a decade or more in actually building projects. This is one reason President Obama discovered to his chagrin that, "There's no such thing as shovel-ready projects."[26]

Despite few changes in federal law, the process of completing EISs has continued to increase in length. A study by the Regional Plan Association (RPA) found that the average length of time to complete an EIS increased from slightly over two years in the 1970s to eight years by 2011.[27] A 2008 study by Piet and Carol A. DeWitt found that the time required to complete an EIS was increasing at a rate of 37 days per year.[28] A report by Philip K. Howard cites the example of a project to merely raise the bridge deck on the already existing Bayonne Bridge in New York: The environmental reviews for this basic project totaled around 20,000 pages and took five years to complete. According to Howard's analysis, in several categories of infrastructure, the cost of a six-year delay in building projects resulting from environmental review adds up to more than the ASCE's estimates of what it would take to pay for needed repairs.[29] The cost of delays is higher than the cost to build.

And after the Port Authority completed those 20,000 pages of environmental reviews for the Bayonne Bridge project? Remonstrators sued to stop it anyway, arguing that the government had not sufficiently studied the environmental impact of the bridge.[30] This is hardly the only case. Environmental litigation to stop projects is now routine. These are almost invariably attempts to accomplish through environmental law what could not be accomplished politically. Trying to stave off or win lawsuits is one of the drivers of today's longer and more complex EISs. As the RPA notes, "The threat of environmental lawsuits motivates lead federal agencies to take time-consuming steps or redesign projects to avoid them, contributing to project delivery delays."

The fact that these delays are the major source of project delays is amply illustrated by the case of the I-35W bridge collapse in Minneapolis. Quickly replacing this major interstate bridge that carried more than 400,000 cars per day was obviously critical. The state managed to do it in only fourteen months. The RPA notes that this project received no environmental waivers. Yet clearly there was political commitment at all levels to make sure this project was not held up by red tape or lawsuits, and that permits were issued promptly. The I-35W bridge replacement shows what it is still possible to do in America if we don't tie our own hands with needless and endless study. This should be the rule more than the exception.

5 FEDERAL FUNDING STRUCTURES ARE POORLY ALIGNED WITH INFRASTRUCTURE NEEDS

Another challenge the Trump administration faces is that existing federal infrastructure programs are largely not aligned with America's infrastructure needs. Consider two simple areas: roads and sewers.

The modern highway finance system dates to the passage of the Federal Aid Highway Act in 1956, passed to provide funding to build the Interstate Highway System. It is financed by the federal gas tax, providing grants to states for highways (with some allocated to metropolitan areas) and financing the federal government's transit programs.

As noted above, the major roadway system of the United States is not in terrible condition. There is a segment of America's roadway system that does have a maintenance problem, however: its local streets.[31] Yet local streets are largely ineligible for federal funding. This non-federal aid mileage accounts for 86 percent of the total roadway mileage in the United States. Major roadways like interstate highways account for most travel volume and are clearly worthy of special concern. Nevertheless, many of America's roads that are in poor condition are precisely these local streets. No matter how much money the federal government pumps into its highway funding structure, it will not do anything to help cash-strapped municipalities with this problem.

The backlog of local repairs is significant. Atlanta's 2013 figure is $922 million for infrastructure needs;[32] Seattle's 2010 estimate was $1.8 billion,[33] with $1 billion for Portland[34] and $3.6 billion for Los Angeles.[35] Many of these backlogs are, naturally, in economically struggling cities; many more cities don't have a handle on their problems and don't even have an estimate. One that does have an estimate is Toledo, with $1.3 billion in needed street repairs.[36] Where is a city like Toledo supposed to come up with that kind of money?

In short, the streets where many Americans live, especially those who are being economically left behind, cannot be fixed by the existing federal funding system, even with infinite spending.

It is a similar situation with sewers. America's cities face billions of dollars in repairs for aging sewers, much of it imposed by the federal government. Just take one example: fixing so-called combined sewer overflows (CSOs). When sewers were first installed in America cities, they frequently combined sanitary waste from homes with stormwater runoff from streets into the same pipe system. In heavy rains, these can overflow, causing untreated sewage to spill into area waterways. Under the Clean Water Act, the EPA is forcing cities to largely eliminate these overflows, no matter what the cost. The agency has sued numerous cities over the issue. Of the 31 consent decrees the EPA has obtained from noncompliant cities, the estimated cost of fixing just this one sewer problem is $29 billion. Combined sewers are often in older, postindustrial cities struggling with a mountain of problems and high poverty levels.

The federal government used to provide grants for water and sewer projects but eliminated these long ago, leaving very little federal help available for these cities. As Springfield, Ohio, mayor Warren Copeland complained to his local newspaper, "This is the biggest, hugest unfunded mandate that I've ever seen in the time I've been in public life. Basically, the EPA at the federal level is prepared to tell us that we have to keep spending money and there's no help from the feds to deal with it. It's just a disaster from my point of view. There doesn't seem to be any way out of it."[37]

What is true for sewers is also true for water systems like Flint's. While that city received special federal and state help, dozens of other cities have been left high and dry.

In short, simply pumping more money into the existing funding structures will completely fail to address many of America's most pressing infrastructure problems.

Some economists might argue that it makes no sense to spend $1.3 billion in Toledo, or to spend to fix sewers in Ferguson or Springfield. If they want to triage American communities and effectively write off vast tracts of America, they should have the integrity to say it explicitly. Clearly priorities have to be set, and not every need can be met in the short term. But to the extent that we as a nation decide that we actually do care about struggling communities, we need to align spending programs with their needs. At a minimum, repair of the existing infrastructure in these communities is one thing we know we can accomplish.

6 PRIVATE CAPITAL ALONE CAN'T SOLVE THE PROBLEM

President Trump has pledged to undertake a $1 trillion plan to rebuild America's infrastructure. While nothing specific has been proposed, early reports suggested that it would lean heavily on private capital.

Many have argued that pension and similar funds could potentially be large-scale investors in infrastructure projects. These funds are chasing stable, quality returns in an era of low interest rates, and infrastructure seems to fit the bill. Infrastructure projects where there are high-quality revenue streams attached are good potential candidates for private equity investment. Toll roads, bridges, and airports around the world are owned or operated by private entities.

But private capital is not free money. Investors expect to both make their capital back and earn a profit. This will ultimately come from users of the facility. From an economic point of view, this makes a lot of sense. The problem comes in when the facilities are in economically struggling communities.

A private firm might buy Flint's water utility and replace all the lines, but ultimately that cost would have to be born by the residents of Flint through higher water bills. One reason why so many of these communities have accumulated such a huge backlog of infrastructure needs is because their citizens cannot afford to pay for them, or can't afford to competitively disadvantage their communities by raising taxes or utility rates. That is not to excuse their frequently poor political leadership, but the problem of fiscal capacity is real. For example, the Saint Louis area's plan to retrofit its sewer system to comply with federal mandates will double or triple the bills of people in troubled Ferguson.[38]

Moreover, much of the infrastructure deficit we face as a country arises from costs such as environmental remediation, for which there is a public purpose but not enough of a revenue stream to satisfy a private investor. Another large chunk is not amenable to private investment because it is in localities where the citizens and business community have limited ability to pay. America's infrastructure problems cannot be solved with private investment only. More tax dollars will be required.

In addition, even in cases theoretically conducive to private investment, actual experience in the United States suggests it will be harder to pull off successfully than many might think. Consider the case of Chicago's Midway Airport. That city received special federal permission and tried twice to privatize Midway Airport by leasing it to investors, failing both times. In 2008, former mayor Richard M. Daley announced a deal for $2.52 billion to lease the airport for 99 years to a consortium led by Citibank.[39] But that deal fell apart after the consortium failed to obtain financing.[40] Mayor Rahm Emanuel tried a second time but likewise failed: the deal attracted only two bidders, but one backed out, forcing the city to scrap the tender.[41] The fact that a highly motivated Chicago failed twice to close a deal for this high-profile and well-patronized airport suggests that airport privatization in the United States is not as simple a matter as supporters might suggest.

It's the same story with private investment in highway and bridge projects. Many of these transactions have not gone well. A number of the opera-

tors of privately run toll roads and bridges have gone bankrupt. Even in rapidly growing Texas, the concessionaire operating the SH 130 toll road near Austin went bankrupt.[42] The company operating the Foley Beach Express toll bridge in Alabama went bankrupt.[43] The operator of the South Bay Expressway in San Diego went bankrupt.[44] Some of these bankruptcies have spawned litigation, with accusations that the deals were done using fraudulent traffic projections.[45] A private consortium that leased the pre-existing Indiana Toll Road from that state for $3.9 billion also went bankrupt.

In one sense, these bankruptcies might be good news for taxpayers. They revealed that the companies had overpaid. In places like Indiana, this created a windfall gain for the public. But these bankruptcies led private firms to shift strategies, away from skin-in-the-game equity deals toward the so-called availability payments model.[46]

In an availability payments contract, a private consortium builds, maintains, and operates a toll facility over a period of time. In return, the government entity promises a fixed stream of payments to the consortium for making the roadway or bridge "available." The new East End Bridge near Louisville[47] and the Goethals Bridge replacement by the Port Authority of New York and New Jersey[48] are using the availability payments approach.

There is nothing wrong with availability payments per se, but these contracts hardly constitute what has usually been meant by private investment. Because the vendors are entitled to their payments regardless of the revenue stream, they have shifted the revenue risk—the biggest risk, and the one that bankrupted all those toll roads—back onto the government. In effect, this is just a fancied-up form of traditional debt financing.

Chicago looms large as a cautionary tale about the limits of private investment and what can go wrong with privatization. Beyond the Midway privatization failures, in 2006, the city leased its downtown parking garages for $563 million for 99 years. This appeared to be a great deal until it later came out that the city had included an onerous no-compete clause in the contract. Not only did the city itself agree not to build any competing garages, it also promised not to allow any private companies to build competing facilities. This was a highly dubious use of government power. Even worse, the city actually did allow a competitor to open, which exposed them to damage claims. The city ended up paying $62 million in compensation to the vendor they had privatized city garages to.[49]

No-compete clauses are common in privatization contracts and examples of "submarine" clauses that can unexpectedly surface and torpedo a government at some future date. Having used no-compete clauses to his own advantage, such as in the deal to open the Grand Hyatt in New York, President Trump must surely understand how easy it would be for sharks to take advantage of cities and states the same way.

More recently, Mayor Emanuel tried another way to use private capital for financing infrastructure improvements in his city. He devised his so-called Chicago Infrastructure Trust (CIT), announced to great fanfare at a ceremony that included former president Bill Clinton. He hoped to raise as much as $1 billion in private capital to finance projects such as $200 million in energy efficiency retrofits of public buildings. The CIT struggled to execute and has completed only one project to date, a vastly downscaled energy retrofit program that ended up being less than a tenth of the size originally envisioned. A report by the nonprofit watchdog group Project Six found significant problems with that transaction, too: the deal included what was in effect $2.2 million in loans to replace light bulbs and install weather stripping, repairs that should never have been debt-financed.[50] It also gave Bank of America, the financier on the project, a lien on all the equipment installed in city buildings as collateral. Furthermore, there appears to be no compelling reason why the city needed to use complex, non-traditional financing for the project.

Chicago's use of privatization and private capital for its infrastructure has arguably been a net negative for the city. If a sophisticated financial center like Chicago cannot get it right, this bodes ill for other, less experienced states and cities.

As President Trump might say, too many of America's leaders have been stupid when it comes to deal-making on private sector investment into transportation infrastructure. If states and cities cannot make smarter deals, they need to stick to traditional tax- or bond-financed public sector infrastructure development.

7 POLICY RECOMMENDATIONS

Any plan to make America's infrastructure great again has to address both the policy needs and the political realities facing the Trump administration.

In the short term, Trump should look to build momentum for infrastructure renewal by finding five to ten more I-35W bridge–type projects with low environmental impact that can be delivered on an accelerated basis in less than two years. Bridge replacement projects would be ideal to improve safety on some of these aging facilities. He should also build on the Obama administration's program to accelerate environmental reviews for as many projects as possible and aggressively use all authority he has to issue environmental process waivers.

A longer-term program should include reforms to the environmental review process to dramatically speed up project timelines as well as to limit the scope of litigation. The president should look for bipartisan solutions

here: Environmental review dramatically delays and increases the cost of projects that are of critical importance to Democratic constituencies, too, including urban transit projects. Researchers of multiple political persuasions, like Philip K. Howard and the RPA, have already conducted significant analysis of the problems and potential solutions, some of which could include better basic up-front coordination between the agencies involved in reviews (or potentially even creating a one-stop federal shop) and limiting the scope of litigation over projects. It is possible to both protect our environment and get projects built in a timely fashion.

Trump must also realign federal infrastructure spending with needs. This means limiting the use of funds for expansion projects in favor of maintenance. No more boondoggles. State and local politicians will always favor new projects over repairs, so federal funding should be heavily focused on maintenance in both highway and transit funding. One priority area should be rehabilitating aging rail systems in America's legacy rail transit cities, including New York, Boston, Philadelphia, Chicago, Washington, and San Francisco—high-ridership systems that are critical to the economies of these major metro areas. Another is replacement of structurally deficient bridges. The federal government could potentially help municipal governments temporarily with local street repairs, which are often shovel-ready projects, as it did during the Obama stimulus. But ultimately state and local governments need to take the lead in establishing an adequate funding structure for local streets.

Trump should also reinstate federal grants for sewer and water rehabilitation and environmental compliance. The expense of these items for many communities is enormous and often imposed by the federal government itself, such as in the case of combined sewer overflow remediation. Paying for these unfunded mandates is only fair. Beyond that, many poor, post-industrial communities simply lack the funds. The federal government should also accelerate brownfield remediation in these communities. These are the very places Trump promised to help in his campaign: they have significant needs, heavy poverty, and large minority populations that have been left behind.

There are select, high-profile infrastructure expansion projects where the federal government should be involved in financing and driving them to completion. These might include the Gateway Project to build new rail tunnels under the Hudson River in New York and the FAA NextGen air traffic control system. The recent derailments at New York's Penn Station that caused travel chaos show why rail upgrades are critical; there is no slack in the system if anything goes wrong. Air traffic control upgrades are needed to help unclog the congested airspace around our cities. Any such projects should be heavily vetted to avoid funding boondoggles. Too much of the money we spent today ends up wasted on "road to nowhere" projects.

Where will the money come from? Let's be honest here: more debt or higher taxes and fees. There is definitely a role for the private sector in financing improvements to major airports and other high-quality, revenue-producing assets. But this will simply not address most of the needs the country faces. States and localities need to be willing to bite the bullet and do the same. Doing things like underpricing utility fees by forgoing maintenance needs to end. The illusion that we can get something for nothing has been part of what brought us to this point. If we want to make America's infrastructure great again, we must be willing to pay to make it happen.

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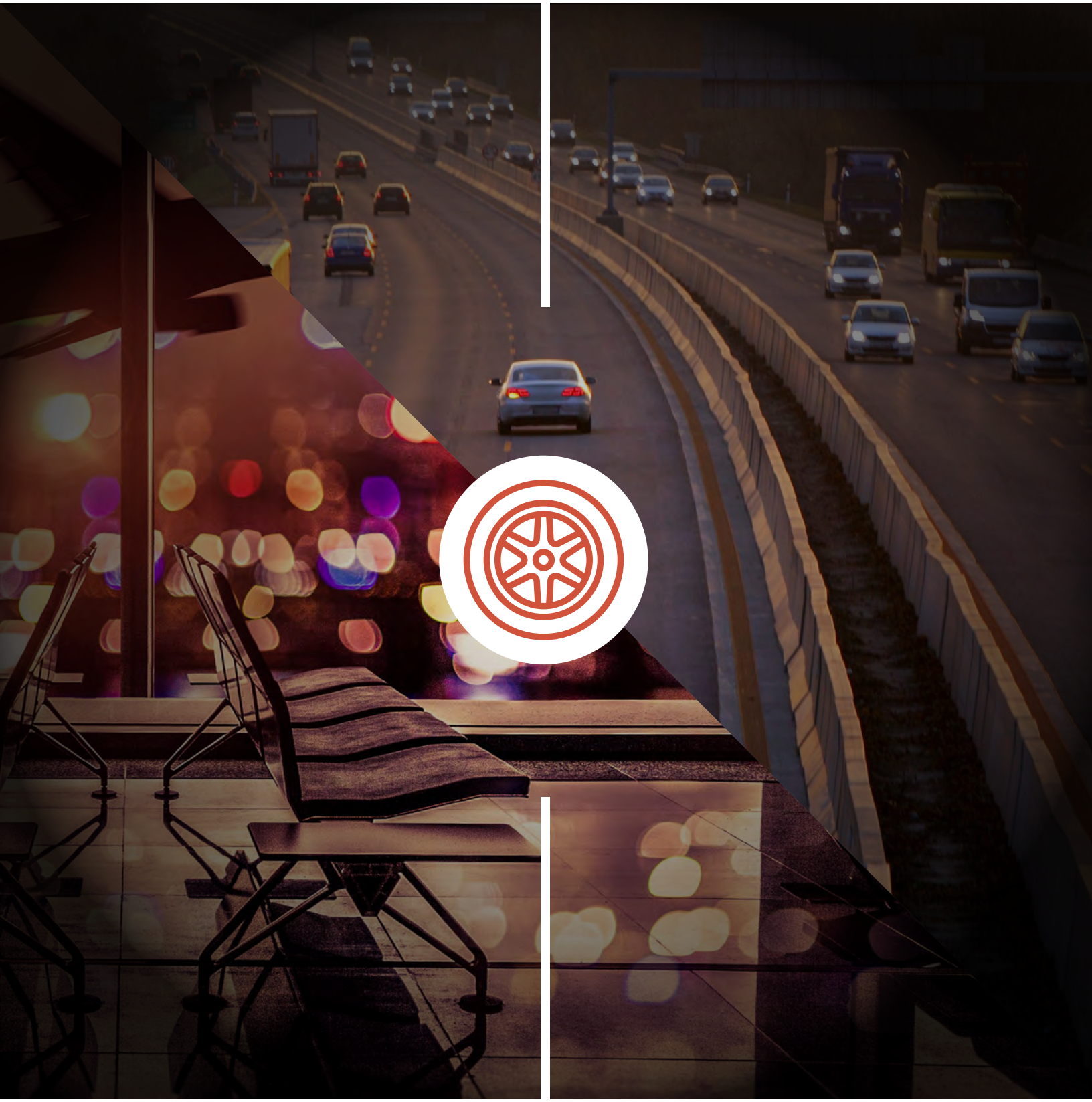

TRANSPORTATION

DRIVERLESS CARS
AND THE FUTURE OF AMERICAN INFRASTRUCTURE

AARON M. RENN

Infrastructure spending in the U.S. is heavily influenced by political, not economic, criteria—and cutting a ribbon to open a new or widened highway makes for great optics. Whether the project can be justified by a cost-benefit calculation is not always the main consideration. As the Congressional Budget Office (CBO) noted last year, "Spending on highways does not correspond very well with how the roads are used and valued."[2]

Quite apart from decisions to build new roads that are skewed by political considerations, it's also the case that return on investment from new roads has simply been declining over time. In part, this is because the U.S. already has an extensive transportation network of railroads, highways, and air routes.

Building the initial networks provided large amounts of value by significantly reducing transportation costs. Subsequent additions to the highway network post-1980 have generated significantly less value. The CBO has noted as much: "Research suggests that the increases in economic activity from spending for new highways in the United States have generally declined over time."[3] Harvard economist and Manhattan Institute senior fellow Edward Glaeser confirmed these findings: "There have been diminishing returns to building new roads, particularly since we completed the National Highway System."[4]

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Glaeser's conclusion is no outlier. A 2013 meta-analysis by Pedro Bom and Jenny Ligthart of 68 studies conducted between 1983 and 2008 showed declining returns on highway investment.[5] One of the studies that they looked at suggested that the return on new highways in the 1980s and 1990s had already dropped below 5%. Conversely, maintenance yields returns of 30%–40%.[6]

Nevertheless, about 35% of federal highway funding continues to go to new or expanded highways instead of the backlog of repairs on the existing system.[7] A few examples: the state of Ohio recently spent $160 million to build a bypass around the town of Nelsonville, population 5,400.[8] The state of Iowa is widening US 20. Maryland is widening MD 404.

The point is not to critique this or any other specific project but to show that American states are extensively building new highways as well as widening existing highways. The relative lack of expansion in key northeastern metro areas such as New York or Boston can give a misleading impression to policymakers, who often bemoan—inaccurately—the lack of highway expansion.

For a measure of the poor return on investment (ROI) on expansion projects, consider the failure or underperformance of various privately financed toll-road projects. Even in rapidly growing Texas, the concessionaire operating the SH 130 toll road near Austin, which opened in 2012, went bankrupt in 2016.[9] The company operating the Foley Beach Express toll bridge in Alabama opened in 2000 and went bankrupt in 2013.[10] The operator of the South Bay Expressway in San Diego went bankrupt in 2011, after opening in 2007.[11]

In these cases, traffic and revenues fell far short of projections. As it turned out, drivers' willingness to pay tolls—that is, to pay the cost of constructing and operating the highways in question—was less than anticipated. In other words, the value of the road to motorists had a negative ROI. While toll financing, which charges the users of highways for their cost, is preferable to paying for new roads with tax dollars, these bankruptcies also suggest that President Trump's proposed $1 trillion infrastructure plan, which relies heavily on private investment and tolls, may not generate the anticipated results.

Alongside the poor returns for many expansion projects, America has a significant backlog of critical maintenance needs. Many estimates, such as the wellknown Infrastructure Report Card,[12] published by the American Society of Civil Engineers, are produced by organizations with a stake in increased infrastructure spending. But even if the exact needs are difficult to quantify, the legitimate repair needs appear to be considerable.

According to a recent report from the transportation research organization TRIP, 20% of the nation's major roads are in poor condition. In urban areas, that number rises to 32%.[13] The Reason Foundation's Annual Highway Report lists a fairly small number of interstate highway miles in poor condition, only 5.4% in urban areas, but this value is trending upward.[14] The Federal Highway Administration reports that 9.6% of America's bridges are structurally deficient, but this still means that 59,000 bridges need to be fixed.[15] (Reason's report says that 20% of bridges are deficient.)

Estimates of the maintenance needs of America's highway systems vary widely; but in all cases, a significant number of roads and bridges require repair—and the money currently being spent on speculative system expansion could be profitably redirected.

1 INFRASTRUCTURE AND DRIVERLESS CARS

Google is currently testing autonomous vehicles on the streets of Austin and elsewhere; Uber's driverless cars are cruising in Pittsburgh and San Francisco. A driverless tractor-trailer using Uber's technology recently made a 120-mile beer delivery run for Coors.[16] Apple is working on driverless cars. And the traditional auto companies are gearing up to compete against these technology companies by developing autonomous vehicles—cars as well as trucks.

Numerous technical, legal, and other challenges must be addressed before autonomous vehicles are ready for deployment to ordinary customers. But the fact that actual test vehicles are already on the road suggests that this moment might not be that far off.

There has been tremendous speculation about what autonomous vehicles will mean for American society. Articles on their potential impact have appeared in a large number of publications, including *New York magazine*,[17] the *New York Review of Books*,[18] and the *Harvard Business Review*.[19] Most agree that their impact could be vast, including:[20]

- Significant economic displacement. About 4 million people work as truck drivers, for example; their jobs are at risk.
- Radically changing the ownership model of vehicles. Some suggest that people in the future will access a shared fleet of driverless cars rather than own an individual one.
- Eliminating the traffic-enforcement function of policing, which would deprive local government of moving-violations revenue.
- Pervasive change or the elimination of entire industries such as car dealers and insurance agents, with follow-on effects in state and local politics, where these constituencies are currently very powerful.
- Expansion of the surveillance state as autonomous vehicles connected to the cloud upload sensory data in real time.
- An increased shortage of organs for transplantation, as fewer organ donors die in accidents.

While it's impossible to predict whether any of these changes will

actually come to pass, it seems likely that autonomous vehicles could represent a major economic and even social inflection point. That is, they will be more like an entirely new mode of transport than merely another feature extension of the automobile as we know it.

This innovation introduces significant uncertainty into our requirements for transportation infrastructure over the medium and long term. Consider the effect of autonomous vehicles on congestion alone. One study projects that "the adoption of AVs will likely result in higher per-capita VMT due to latent demand."[21] Another predicts: "When fleet penetration reaches 95% and when non-drivers are permitted to travel in robotic cars, VMT increases may reach as high as 35% on portions of the transportation network."[22]

How might driverless cars lead to more congestion? First, they could be used widely by those currently too old or too young to drive. Second, people could easily become more tolerant of longer commutes if their travel time is productive. And third, so-called deadheading, in which empty vehicles, such as those exiting a city center to park at a remote site or to return to the owner's home for another family member to use, could lead to a serious increase of vehicles on the road.

On the other hand, autonomous vehicles hold the promise of making highways much safer and more efficient. "The reduction of traffic crashes and consequent secondary incidents alone," one study suggested, "will lead to significant efficiencies in traffic operations by reducing non-recurrent congestion, because 25 percent of traffic congestion can be attributed to traffic incidents such as crashes and vehicle breakdowns. At high market penetration, AV technology potentially can make it possible to move toward an advanced form of vehicle platooning in which convoys of vehicles move at high speeds and small spacing in between. This approach is being tested in the trucking industry, in which a number of driverless trucks are coupled and led by a human-driven truck."[23] Another study suggests that "when regulations, liability concerns and driver comfort allow much more aggressive car-following algorithms, vehicle delays may be reduced by 45% or more."[24]

Which of these effects will predominate? How much traffic will there actually be in the future? How much highway capacity will be required? Will driverless cars require different types of roadways to be built?

These questions are very much up in the air. But what we can say with certainty is that the advent of autonomous vehicles materially increases uncertainty about both the type of infrastructure that we will need and the highway capacity required, making speculative investment today unwarranted.

2 "PEAK CAR" AND THE FUTURE DEMAND FOR TRAVEL

Starting in 1950, total VMT had been increasing at a rate faster than population and jobs **(see Figure 1)**. This was true for per-capita VMT as well. There were a very small number of short-term interruptions, such as the time period around the 1973 Arab oil embargo; but overwhelmingly, the trend was up.

This changed starting in the 2000s. Total VMT fell, starting in 2007, and continued until 2011. Per-capita VMT **(see Figure 2)** started falling in 2005 and continued through at least 2013. (Per-capita and total VMT can move in different directions because the total U.S. population is growing.)

One obvious factor behind this decline was the onset of the Great Recession; it's unsurprising to see that total VMT began falling in 2007 as Americans lost their jobs and incomes. But there may be other forces at work.

Many argue that driving demand is unlimited. This is embodied in the idea of so-called induced demand, which holds that when a new highway is constructed, that new road (increased supply) will tend to increase the quantity of driving consumed because it lowers the price of driving (in the form of reduced congestion, more direct routings, and so on).

This is true so far as it goes. But the logic of induced demand also insists that any attempt to address traffic congestion by building more roads or widening more roads is futile because those roads will simply fill up with new cars until they are equally congested.

But there may be a countervailing force, "saturation": at some point, there is simply little to no further demand for driving to satisfy. Traffic engineers as far back as the 1950s anticipated that per-capita VMT would level off at a future date. In fact, a 1974 British study predicted that that country would reach a saturation point in 2010, close to the time in which British VMT did, in fact, peak and start to decline.[25]

David Metz, a researcher at University College London and formerly chief scientist of the U.K. Department for Transport, states: "Saturation of daily travel demand is to be expected and is a likely explanation for the observed cessation of per capita growth of personal travel."[26] He bases his claim on the diminishing marginal utility of additional car travel.

Metz points out that 80% of Britons already have three supermarkets within a 15- minute drive. In many categories, ample choices are already available within easy driving distance and within each person's daily travel budget, which he estimates as a historical constant of about one hour. There's limited need to drive more and farther to access more opportunities, except in a limited number of places with unique amenities or employment characteristics.

This saturation effect exists independently of any other effects that might limit or even reduce travel demand, such as claims that the current generation of young people prefers walking, bicycling, and public transit to a greater extent than previ-

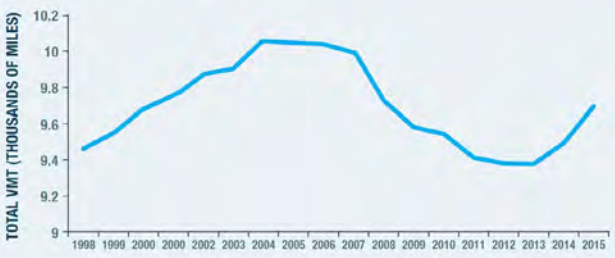
FIGURE 1.

Total Vehicle Miles Traveled (in Millions of Miles)

Source: Federal Highway Administration

FIGURE 2.

VMT per Capita, 1998–2015



Source: Federal Highway Administration, "Moving 12-Month Total Vehicle Miles Traveled," retrieved from FRED (Federal Reserve Economic Data), Federal Reserve Bank of St. Louis

ous generations did.

Both total and per-capita VMT resumed their upward climb, beginning in 2012 and 2014, respectively. Total VMT has reclaimed its peak, though per-capita VMT remains well below peak. It's possible that the declines were purely recession-induced and the previous trend will resume indefinitely. But given the fact that this decline wasn't anticipated by contemporary traffic engineers, that per-capita VMT declined for nine straight years (as opposed to only two during the Arab oil embargo of the 1970s), and that there are theoretical reasons to believe in a demand saturation point, we should not behave with as much certainty about future traffic increases as we did previously.

In short, even apart from autonomous vehicles, there has been a material increase in our level of uncertainty about future demand for highway infrastructure.

3 CONCLUSIONS

While there may be select regions—for example, Houston—where rapid growth makes highway expansion necessary, the national story is one of uncertainty, thanks to autonomous vehicles and travel-demand saturation. On the national level, the danger is to commit to building highways that can't be economically justified while existing roadways crumble. To avoid this danger, federal policy should be changed in the following ways:

1. Limit or eliminate federal grants for highway expansion. One way would be to restrict federal grants to maintenance only, or to cap the share of expansion projects at a low percentage, such as 5%. Economists Matthew Kahn of UCLA and David Levinson of the University of Minnesota made an interesting proposal for this in 2011 that might serve as a model.[27] Their proposal would: a) restrict federal grants to maintenance only; b) create a highway-specific federal infrastructure bank to finance highway expansion projects that meet a clear economic return threshold; and c) provide lower interest rates on loans for projects that meet various performance standards. Something of this nature could serve as a template for reform.

2. Permit existing highways to be tolled to manage congestion and finance expansion. Rather than expanding highways that are currently congested, one alternative solution is to use pricing to manage congestion instead. This so-called congestion pricing approach has long been used in Singapore and has been deployed in many other cities around the world. It is also already in use in the U.S., such on the SR 91 express toll lanes in the Los Angeles area. This can be implemented with modern electronic toll-collection methods that don't require congestion-creating toll booths.

The bankruptcy of various U.S. toll-road projects noted above shows that drivers are sensitive to pricing. Requiring states to use either 100% state funds or toll revenues to build expansion projects would enforce greater market and political discipline on expansion projects.

3. Limit or eliminate federal funds for rail-transit expansion. About 20% of federal surface transportation spending is directed to transit. Some of this goes to buses, but a significant amount has been badly misdirected to build new rail projects in cities with limited histories of rail transit and infrastructure designed overwhelmingly around the automobile. These projects, like Dallas's light rail system, are even more speculative than highways.

Meanwhile, the existing rail system in Washington, D.C., has experienced severe problems due to a lack of maintenance. The same is true in Boston. New York City's subway signals are many decades old and obsolete, among myriad other maintenance needs. Given the extensive maintenance needs on existing high-volume rail systems, limited federal dollars should not be directed to such speculative enhancement projects.

With the future of transport so uncertain, the government would do well to stay away from the new and stick to investing limited federal resources on what we know will deliver: the maintenance of our existing roads, bridges, and transit lines.

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MAKING NEW YORK'S AIRPORTS GREAT AGAIN

JOHN TIERNEY

For once, Donald Trump was guilty of understatement. "Our airports are like from a Third World country," he complained during the first presidential debate, describing the experience of landing in New York. He was echoing a common complaint—Vice President Joseph Biden had previously used "Third World" to describe La Guardia—but Trump wasn't adequately diagnosing the problem. Comparing New York's airports with the Third World's is unfair to the Third World.

Even in the poorest countries, a traveler can expect to reach an airport terminal by automobile, but the traffic congestion at La Guardia has gotten so nightmarish that passengers are jumping from cabs along the highway and schlepping their bags on foot to the terminal. Passengers often rank La Guardia as America's worst airport, infamous for its leaky ceilings, claustrophobic corridors, and seedy bathrooms. Yet, by some measures, it isn't even the worst local airport. As dingy as it is, La Guardia can't match Newark Airport when it comes to gouging passengers, who've seen their fares rise and rise to cover the most expensive landing fees in the country. In the Third World, people typically can fly out of their home city, but prices are so high at Newark that northern New Jersey residents often drive two hours to Philadelphia to find affordable flights.

Why are passengers paying so much to get so little? Because American airports are terribly managed, by global standards, and New York's airports are the worst-managed in America. Among the world's top 100 airports, as determined by the annual Passengers Choice Awards, the highest-ranked American airport is Denver—in 28th place, far behind the major airports of Europe, Asia, and the Middle East. New York has the second-busiest airport system in the world—only London handles more travelers—but its best airport, JFK, ranks just 59th. Newark and La Guardia don't make the list.

Outside the United States, in cities such as London, Paris, Madrid, Zurich, Frankfurt, Rome, Istanbul, Mumbai, Sydney, and Buenos Aires, public-private partnerships are transforming the industry, with airports getting sold or leased to private-management companies that focus on pleasing passengers. To make a profit, these managers must hold down costs, while enticing customers with lots of flights, competitive fares, and terminals with appealing stores and restaurants. London's three airports have improved dramatically since they were privatized—first as a

single company, and then divided into three separate firms so as to encourage competition. Heathrow, currently eighth in the international ranking, has been so intent on attracting passengers that it built and runs a nonstop express train linking the terminal to central London. To deal with surging demand, its management company is seeking to add another runway, as is the rival company in London running Gatwick Airport.

In the United States, by contrast, airports are still typically run by politicians in conjunction with the locally dominant airlines, which help finance the terminals in return for long-term leases on the gates and other facilities. Keeping costs down and customers happy are not the highest priorities. The airlines use their control of the gates and landing slots to keep out competitors so that they can charge higher fares; the politicians use their share of the revenue to reward supporters, especially the unionized airport workers who contribute to their campaigns.

In New York, these problems are even worse because of decisions made in the 1940s to give an airport monopoly to the Port Authority of New York and New Jersey—perhaps the most inefficient and least accountable public agency in America. If O'Hare Airport were as dilapidated as La Guardia, Chicago voters could punish the mayor responsible for it. If the San Francisco airport set landing fees as high as Newark's, it would lose business to Oakland's airport, which is run separately and competes to attract airlines and passengers. But New York's three major airports—and three smaller ones—are under the control of an agency that's unresponsive to voters. No single politician ever gets blamed, because the Port Authority's executives and board members are appointed by the governors of New York *and* New Jersey.

When the agency was created in 1921, the rationale for its unwieldy structure was to enable the two states to cooperate on projects to improve the port, starting with a railroad tunnel under the Hudson River. But the agency never built the tunnel. Instead, aided by the Progressive era's naive faith in rule by independent experts, it became a bureaucracy unto itself, expanding its turf by taking on projects that didn't cross state lines. On their own, New York and New Jersey could easily have built and managed their own airports, and the competition between them would have benefited the public. If La Guardia were an independent airport, it would pay a price for the traffic mess generated by its current renovation project, which is leading many passengers to shun the airport. But because most of these travelers wind up using JFK or Newark, their money still goes to the Port Authority, anyway. The agency's managers bring to mind the phone operator on early episodes of *Saturday Night Live*, played by Lily Tomlin during the Bell-monopoly era: "We don't care. We don't have to."

Freed of competition, the Port Authority has run up its expenses at the airports, chiefly through the above-market salaries and pensions extracted by its politically powerful unions. It spends $156,000 in wages and benefits per worker. (See "Bloated, Broke, and Bullied," Spring 2016.) Even with these stratospheric costs, the Port Authority charges such high fees that it makes a hefty profit on its three major airports. In most other cities, these revenues would help maintain and upgrade the terminals and runways and other facilities because federal law generally forbids local politicians from diverting airport revenues to non-aviation purposes. But the federal law, passed in 1982, contains a grandfather provision that has let the Port Authority continue diverting billions of dollars of airport money to cover the ongoing losses of its other operations—such as the PATH commuter train from New Jersey to New York, the midtown bus terminal, and the World Trade Center reconstruction project.

That's the biggest reason New York's passengers pay so much to get so little: their money isn't reinvested in the airports. While London's airports were being modernized, New York's were allowed to deteriorate. While London's airports are preparing to add runways, the Port Authority is making no similar efforts to expand capacity in New York, despite the obvious need. It has consigned passengers to long waits in aging terminals, staffed by often unresponsive workers.

The Port Authority's three big airports rank at the bottom of an analysis of flight delays at major American airports conducted by Nate Silver at the FiveThirtyEight blog. After controlling for weather delays and other factors, Silver calculated how many extra minutes a passenger would be delayed on a typical flight leaving or arriving at each airport. New York's three airports were the only ones in America with an average delay of at least 19 minutes for both arrivals and departures. The worst was La Guardia, with an average delay of 27 minutes for an arrival and 30 minutes for a departure. The local delays are due partly to the Northeast's congested skies and to an inefficient air-traffic-control system—also woefully backward, by world standards. But the delays wouldn't be so bad if New York's airports hadn't been stripped of revenue needed to build runways and other facilities to meet rising demand.

New York's airports also dominated the bottom of the rankings of American airports in surveys of passenger satisfaction by J. D. Power, by the Points Guy, and by *Travel & Leisure* magazine. La Guardia secured last place, the magazine explained, by having "the dubious honor of ranking the worst for the check-in and security process, the worst for baggage handling, the worst when it comes to providing Wi-Fi, the worst at staff communication, and the worst design and cleanliness." And that survey was done before the chaos unleashed by the current renovation project.

The Port Authority has diverted so much money from the airports and run up such massive debts on its other projects that it can't afford the bill for La Guardia's renovation. That work is being financed partly by Delta Airlines, which is renovating its own terminal, and partly by a private con-

sortium that will build and manage a new central hall and terminal. This public-private partnership with the Port Authority is a welcome development, but it still leaves New York far behind the rest of the world. The private consortium is leasing just one terminal, not the whole airport. And La Guardia is still ultimately part of the same Port Authority monopoly as JFK and Newark. Passengers would be better served by putting each airport under the control of an independent manager, as was done with the London airports.

The successful results in London impressed New York mayor Rudy Giuliani, who moved to break up the airport monopoly in 2000. He criticized the Port Authority for letting the airports deteriorate by diverting $150 million of airport revenue annually into other projects. He proposed reasserting New York City's control over La Guardia and JFK, which are city property, by ending the Port Authority's leases and bringing in private managers. The city considered bids from four companies—including the managers of airports in Amsterdam, Düsseldorf, and Zurich—and ended up choosing the British firm in charge of Heathrow. "We drafted an agreement to privatize the airports and began negotiating with the Port Authority," recalls Anthony Coles, then a deputy mayor. "They were resistant, but we were making some progress on it in 2001." Then came the attacks on September 11. After that, says Coles, "it wasn't anyone's priority anymore, so it never went any further with us."

The next mayor, Michael Bloomberg, didn't pursue it, and neither has Mayor Bill de Blasio. But as the airports continue to fall behind the rest of the world, the notion of wresting them from the Port Authority makes more sense than ever. John Schmidt, an attorney at Mayer Brown who has negotiated public-private partnerships at airports around the world, says that plenty of experienced managers are eager for the New York challenge. "When it comes to privatizing New York's airports," he observes, "the universal view of the world's major airport operators is incredulity that it wasn't done long ago, particularly at La Guardia." Ever since Margaret Thatcher privatized British airports in the 1980s, that approach has become routine in the rest of the world. Today, three-quarters of passenger traffic in Europe is handled by airports that have been fully or partially privatized. But privatization has been blocked in the United States by federal policies as well as local resistance.

The result has been much poorer management in the U.S., particularly in airports structured like the ones in New York, as a team of economists concluded after analyzing more than 100 major airports around the world. The economists, led by Tae H. Oum of the University of British Columbia, found that airports run by cities or other local governments were typically less efficient than those run either by private companies or by public authorities dedicated solely to the airports. The lousiest airports of all were those in the United States run by port authorities that oversaw both seaports and airports. The economists concluded that Americans should "reconsider ownership and management of airports by port authorities."

That advice has little appeal to the politicians, unions, and airlines comfortable with the status quo at the Port Authority. But now, there's an opportunity in Washington to help air travelers in New York and the rest of the country. Donald Trump campaigned on a promise to improve America's infrastructure, and with Republicans in control of Congress, they can expand their efforts to reform aviation. In the past, they've often been stymied in this aim by Democratic opposition, but they do have one success story to build on. If you want to see how much better airports could be in New York, or in any other American city, take a plane to Puerto Rico.

Until four years ago, the Luis Muñoz Marín International Airport in San Juan had lots in common with La Guardia. It was run by an unwieldy bureaucracy, the Puerto Rico Ports Authority, which neglected the airport while running up bills on its other unprofitable projects in the island's ports. The terminal was a confusing jumble of dim corridors, with passengers enduring long waits to get through security or pick up luggage. The stores were tacky and the restaurants greasy spoons, often rented at bargain rates to politicians' friends or relatives.

On rainy days, the ceilings leaked; on hot days, the air conditioning faltered. The floors of the boarding bridges from the gates to the planes were riddled with holes. The bathrooms were grimy, and it often took days or weeks to repair a broken toilet. Because of union work rules, changing a lightbulb required four workers, sometimes five—if there was a new bulb available. Some crucial tasks didn't get done at all, such as maintaining the instrument landing system used to guide a plane descending during bad weather. For years, pilots had to land their planes visually, without positional guidance from radio signals, because the system's antennae were blocked by trees—and no one in the bureaucracy wanted to take responsibility for cutting them down. Airlines, unsurprisingly, switched operations to other Caribbean hubs, leaving the airport without the revenue to pay bills, much less make capital improvements. There was no hope of rescue from the Puerto Rican government, which was in terrible financial shape during the island's long-running economic crisis.

The situation got so grim that politicians considered surrendering some of their control over the airport, though that meant sacrificing the patronage that came with it. To dig out of their financial hole, they needed someone from the private sector to pay off their debts and manage the airport efficiently. This solution was difficult to implement in the United States because of obstacles to privatization erected by the major airlines and unions aligned with Democrats. But Republicans in Congress had prodded the Federal Aviation Administration into starting a program that would permit at least a few airports to give it a try.

San Juan became the first—and so

far the only—major American airport to make the conversion. The Ports Authority leased the airport in 2013 for 40 years to Aerostar, a partnership of investors and a company operating airports in Cancún and other Mexican cities. The new managers agreed to make capital improvements and to pay the Ports Authority $1.2 billion—half up-front and half over the course of the lease. They also promised to reduce landing fees and keep them low in the future.

The result, just three years later, is an airport that nobody would call Third World. The redesigned concourses are sleek and airy and easy to navigate. Passengers get through security faster, thanks to a state-of-the-art system for screening bags. New boarding bridges stand at the gates. The duty-free shop now looks like an upscale department store, and revenue from the new stores and restaurants has more than doubled. The renovated facilities and the reduced landing fees have attracted more airlines to San Juan, and they have no trouble getting access to gates—now controlled by the airport's manager, not other airlines. This new arrangement took some getting used to for the dominant airlines, but they're reaping other benefits.

"We're paying lower fees for a much better airport," says Michael Luciano, who has run Delta's operations in San Juan for almost two decades. "Almost every area has been renovated. You go into any restroom, and it's bright and clean—things like that are really important to our customers. The lines at the checkpoints are handled more smoothly. The whole airport experience is different. Things work."

Under the Ports Authority regime, inexperienced political appointees directed the airport; their jobs and plans lasted only as long as their party stayed in power. Now, the airport is run by industry veterans, who take the long view because of their company's 40-year lease. The Aerostar executive in charge of the airport, Agustín Arellano, a former pilot with the Mexican air force, is an aviation engineer with decades of experience overseeing airlines and airports. "A knowledgeable professional like Agustín makes so much difference," Luciano says. "With political appointees, you have to teach each new one how the airport works, and it can take so long to get anything done. Now when there's a problem with a taxiway or a gate or a checkpoint, Agustín understands it and takes care of it right away."

That's precisely what Arellano did with the trees blocking the antennae needed to guide planes landing in bad weather. Airport officials had been waiting eight years for bureaucrats in Puerto Rico and Washington to decide which agency had the authority to remove them. Arellano promptly resolved the impasse. "We went out there and cut down the trees ourselves," he says. "I knew we'd have to pay a fine, and we did—they made us plant two trees nearby for each one we cut down. But we couldn't wait any longer. We had to make sure planes could land safely. Isn't human life more important than trees?"

By eliminating old union work rules, the airport has improved services, while shrinking the staff by a third. Managers use new computerized tools for tracking repairs and spotting problems. The airport is one of the first in the United States to install a system that tracks the flow of people throughout the terminal, enabling managers to see exactly how long it takes passengers to get through lines at airline counters and security checkpoints. When bottlenecks occur, extra workers are dispatched to help out.

"We're trying to change the whole culture of the airport to focus on customer service," Arellano says. That's brought more customers. The volume of passengers in San Juan has been growing at 4 percent annually, well above the industry average. That increase is good for Aerostar's bottom line, of course, but it's also a boon to Puerto Rico. While the rest of the island's economy has floundered and the government has cut back services, its airport has transformed from liability into asset. Arellano sees it as a model for New York and other cities, though he recognizes the political obstacles elsewhere. "The airport

infrastructure in the United States is so old that there's no way the government can afford to modernize it all," Arellano notes. "I realize that the word Ωprivatization≈ is problematic for many people. But it's not as if the public is giving up all control. It still owns the airport in a public-private partnership. The government gets out of debt and acquires a new source of revenue, and passengers get an improved facility managed by professionals. The public comes out ahead."

Suppose that the politicians controlling New York's airports put aside their own interests—this is completely hypothetical, needless to

San Juan leased its Luis Muñoz Marín International Airport in 2013 to a private partnership, resulting in dramatic improvements to its facilities and services.

enough to wipe out the Port Authority's $21 billion debt—and, even better, wipe out the Port Authority itself. The agency's other operations—the bridges and tunnels, the PATH train, the World Trade Center transit hub—could be assigned to other managers concentrating on customer service instead of patronage and empire-building.

If the airports were separately managed, New Yorkers would enjoy the same kind of benefits enjoyed by travelers in San Juan and foreign airports: renovated terminals, better services, lower costs, more flights, cheaper fares, more innovation. To reduce congestion and delays, the managers could add another runway at JFK or Newark, or both, and they could use their control of the gates to encourage competition. Like the managers of Heathrow, they might provide a rail link to the center of the city. In no case would they force passengers to arrive at the terminal by wheeling their suitcases along a highway.

It's a lovely vision, but how—to be non-hypothetical—could politicians be induced to surrender control of the airports?

The first step: prevent them from raiding the airports' coffers to subsidize pet projects. United Airlines is trying to do this, asking the FAA to stop the Port Authority from diverting its Newark revenue. The airline's formal complaint details Newark's "bloated" costs—like the $242,000 in annual compensation per aircraft-rescue worker. It also notes that the airport raises a "staggering" amount of money through landing fees that are "by far the highest" in the country—almost *60 percent* more than the next-highest, O'Hare. Much of this revenue goes to outside projects, which the Port Authority claims is permissible because of the grandfathered exemption in federal law. United argues that the agency's diversions have become so extreme that they're illegal and should be stopped.

Another strategy would be even more effective: get rid of the grandfather exemption altogether. The Giuliani administration formally asked Congress in 1999 to repeal the clause, so that the Port Authority couldn't divert money from JFK and La Guardia. But the Port Authority successfully lobbied to keep the exemption.

This year, though, Congress has another chance to do a favor for New Yorkers—and the millions of travelers who pass through. It will be debating aviation policy in order to meet a September deadline for reauthorizing the FAA, which must be done every few years. Now that Republicans control the White House and Congress, they have a golden opportunity to bring American aviation up to international standards. They're hoping to reduce congestion and flight delays by turning the federal government's antiquated air-traffic-control system over to an independent corporation, as Canada and Britain have done. They're also looking to make it easier for airports to emulate San Juan. The FAA's current program allows just a few airports to experiment with privatization, and then only with the permission of the dominant airlines. If Republicans succeed in eliminating these restrictions and taking away the airlines' veto power, American airports could start catching up with the rest of the world.

It's hard to imagine this ever occurring in New York because the Port Authority would be loath to surrender its airport-monopoly profits. (How would it pay for the rest of its empire?) But perhaps President Trump could help. If he really wants to improve his hometown's airports, he could reprise Mayor Giuliani's strategy: stop the Port Authority from diverting airport revenue. It can do so now because of the grandfather exemption, but Trump could easily insist that Congress revoke the exemption in this year's FAA legislation. This would be a painful shock to local politicians, but it could inspire them to think creatively. It might even occur to them to turn over La Guardia, JFK, and Newark to someone who knows how to manage a First World airport.

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REINVENTING THE PORT AUTHORITY

OF NEW YORK & NEW JERSEY

ROBERT W. POOLE

The Port Authority of New York & New Jersey is America's largest single provider of metro-area transportation infrastructure. The New York–New Jersey Port Authority Compact established the agency in 1921, and the original purpose was to improve the region's seaports. But the broad language of the compact enabled the agency to build toll bridges and tunnels between the two states and, in the 1940s, to operate the region's three major commercial airports. The PA expanded again in 1962, taking over a money-losing heavy-rail transit line that was renamed PATH, and launching the World Trade Center real-estate development in lower Manhattan.

The Progressive-era architects of public authorities like the PA set out to replace the often sordid politics of public procurement with independent public agencies. These agencies would be led by apolitical technocrats—professional engineers, managers, and administrators. That has proved to be a vain hope, as politicized decisions in recent decades have thrust the PA into an array of "economic-development" projects in New York and New Jersey, and the agency has diverted funds to rebuild the Pulaski Skyway, entirely within New Jersey. ***CONTINUED ON NEXT PAGE***

The agency's financial condition is deteriorating. It is also a defendant in a long-running lawsuit by the regional affiliate of the American Automobile Association, which challenges the PA's diversion of revenue from bridge and toll increases to help reconstruct the World Trade Center, instead of using it for bistate transportation projects.

In light of these developments, outside organizations and, indeed, the PA leadership have called for reforms. The goal is generally to return the agency to its core transportation mission by divesting real-estate assets and taking a more businesslike approach to its transportation assets.

The question is whether these reforms go far enough. I think not. The PA needs to undertake more fundamental change, and a review of its history helps explain why.

1 THE PORT AUTHORITY'S RATIONALE AND HISTORY

By the early 1920s, New York Harbor had grown increasingly congested, as the port's docks and wharves proved inadequate to the growing seaborne commerce. Nearly all the region's docks were in New York City, but the railroads that were needed to transport goods to and from the Port of New York were in New Jersey. The result was the creation of a bistate public authority, established by the New York–New Jersey Port Compact of 1921, to develop and operate port and transportation facilities for the benefit of the entire region.

The Port Authority's initial plan was to improve the ports and expand railroad infrastructure. But the agency, short of funds, instead devoted much of its efforts toward building revenue-producing assets: three bridges between New Jersey and Staten Island (Bayonne, Goethals, and Outerbridge) and the George Washington Bridge, between New Jersey and upper Manhattan. The PA acquired the existing Holland Tunnel under the Hudson River in 1931 and built the Lincoln Tunnel, which opened in 1937.

In the 1940s, the PA entered into long-term leases to operate Newark, LaGuardia, and Idlewild (later JFK) Airports. In 1950, the agency opened a large Port Authority Bus Terminal in mid-Manhattan, primarily to serve commuter buses from New Jersey. In the 1950s and 1960s, the agency significantly expanded marine terminal facilities, including the development of the world's first all-container facility at Port Elizabeth, New Jersey.

Still, the PA's infrastructure investments over the first 40 years all dealt with bistate transportation facilities. That changed in 1962. Laws enacted by the legislatures in both states enabled the Port Authority to develop a World Trade Center office complex in lower Manhattan (a New York project) and to take over the bankrupt Hudson & Manhattan Railroad, which became PATH (Port Authority Trans-Hudson), serving New Jersey commuters. In 1979, legislation allowed the PA to build industrial parks and redevelop waterfront land. Similarly, in 1984, legislation enabled the PA to build mixed-use waterfront projects in New Jersey and Queens, New York.

The PA could finance these major moves into real estate because, by the 1960s, bridge and tunnel tolls, along with thriving airport traffic, were generating large surplus cash flows. The agency could tap the money because there were no new projects lined up, and terminal lease agreements with airline tenants were largely funding airport expansions.

Nearly all U.S. commercial airports must use their revenues for airport purposes as a condition of accepting federal airport grants. But PA airports are exempt. That's because they were already transferring surplus airport revenues to non-airport purposes before the enactment of the federal airport grants law in 1970.

The PA's Board of Commissioners comprises 12 members: six appointed by the governor of New York; and six by the governor of New Jersey. Under a long-standing informal arrangement, the governor of New Jersey appoints the board chairman, and the governor of New York appoints the executive director. The agency's large surplus cash flows have proved alluring: the commissioners searched for new projects, including non-transportation real estate, which would win political plaudits in their respective states. It is also likely that the surpluses weakened agency incentives to efficiently manage the airports, toll facilities, and seaports. The idea of an apolitical agency was still well out of reach.

One fact stands out: aside from expanding the Lincoln Tunnel in the 1950s and opening the second deck on the G. W. Bridge in 1962, *there has been no expansion of highway capacity between New York and New Jersey in more than 50 years, despite massive traffic congestion.* And until very recently, adding runway capacity at any of the three major airports has been out of the question. Since the early 1960s, the PA has milked the cash cows—the airports and toll facilities—to subsidize an increasing array of other projects.

2 CHANGE IS IN THE AIR

The PA's declining financial performance—combined with growing concerns over ever-higher toll rates, cost overruns on the World Trade Center reconstruction, and a variety of scandals—has led to proposals for reform in recent years. The first proposal began in September 2011, when a special committee of the PA's board of commissioners asked Navigant (a consultancy) and investment banking firm Rothschild to perform a finan-

cial review of the agency. Navigant's Phase II (final) report in 2012 made some organizational and governance recommendations but did not question the agency's overall business model.1 Rothschild assessed the PA's ability to finance additional projects despite its high debt level, which it found to be adequate.[2]

In 2013, New York's Citizens Budget Commission (CBC; a nonprofit citizens' group) made a series of recommendations to improve the Port Authority's management and budgeting. A year later, the CBC reported that the agency had made progress in some areas but was falling short in disclosing how it made and justified decisions on capital projects, in disclosing the sources of funding for each project and in providing independent monitoring of major capital projects.[3]

New York University's Rudin Center for Transportation Policy & Management released a more comprehensive report in 2014.4 "The fundamental challenge," according to the executive summary, "is that the business model under which the Authority has operated for the past 30 years is no longer sustainable."

"A Port Authority That Works" faulted agency decisions to move into real-estate development and PATH and the subsequent move into economicdevelopment projects. The Rudin Center report also criticized "allocat[ing] a portion of its surplus revenues and its limited capital capacity to projects selected by the governors of the two states, many of which bore little or no relationship to the Authority's mission or its existing businesses."

It documented the PA's eroding financial base, thanks to zero-revenue projects in the two states and soaring operating deficits at the ports, PATH, and the bus terminals. And it pointed with alarm to the continued irresponsibility of doing so once the financial erosion became obvious:

Even as the Port Authority's financial foundations were eroding, the Authority continued to finance projects chosen by the governors. Between 2001 and 2012, the Port Authority spent more than $800 million on such "regional projects." During the next few years, PA spending on zero-return projects will increase even further, as a result of the Authority's agreement to provide $1.8 billion to fund the rehabilitation of state highways in New Jersey.

"A Port Authority That Works" stated that the relentless increase in bridge and tunnel tolls was the "direct result" of the PA's "continuing reliance on its bridges, tunnels, and airports to fund its money-losing operations and to finance both its own and the states' capital projects." The report called for redirecting PA funding to be "solely for facilities, services, projects, and programs that are clearly aligned with its core [transportation] mission." It recommended that the PA divest all non-transportation real estate except for the World Trade Center (which it expects to be profitable), invest more in improving the three major airports, and stop the financial hemorrhage of the PATH system.

Also in 2014, the PA's board of governors created the Special Panel on the Future of the Port Authority, consisting of its chairman, vice chairman, a board member, and the counsels of each of the two governors. The Special Panel released its rather sweeping report in December 2014;5 in February 2015, the board voted unanimously for the panel's core structural and strategic recommendations.

In addition to several changes in governance (e.g., a single CEO and two cochairs, increased transparency), the Special Panel report, *Keeping the Region Moving*, made profoundly important mission recommendations. First, the PA must "return to its core mission of facilitating the efficient movement of people and goods through the region." Second, it must revitalize its core transportation assets: the three airports, the bus terminal, the seaports, and PATH. Third, it must "phase out real estate ownership and development" as part of its mission, including divestiture of its commercial real estate holdings at the World Trade Center. Finally, the PA must update its 1952 Consolidated Bond Resolution to include "facilitating the divestment of noncore assets" and taking advantage of public-private partnerships and other innovative financing tools.

The reform proposals are many, but none of them asks the fundamental question: Is the Port Authority model the best way to plan, finance, and manage the critically important bistate infrastructure? I suggest that the answer is no. The PA itself needs reinvention. A review of the Authority's individual lines of business explains why—and how.

3 PLANES, TRAINS, AUTOMOBILES, AND SHIPS

Airports

Kennedy, LaGuardia, and Newark Airports score very poorly in national and international airport rankings. Many of their terminals are antiquated and undersize. Their retail concession offerings are far below those available elsewhere. And for decades, the Federal Aviation Administration has rationed their landing and takeoff slots, thanks to inadequate runway capacity. Meanwhile, the PA appeared to be more interested in adding to its airport portfolio (by acquiring money-losing Stewart Airport and getting involved in the management of money-losing Atlantic City Airport) than upgrading its three major airports to world-class standards.

The PA's Special Panel report touts the three major airports as "the second largest airport system in the world in passenger traffic (behind London) and the largest in flight operations."[6] Considering these airports as a centrally directed "system" reflects the Progressive-era mind-set. It ignores

the potential benefits to passengers and shippers of healthy competition among these airports.

London's Heathrow, Gatwick, and Stansted Airports were operated as a system when they were part of the British Airports Authority. The Thatcher government privatized BAA in 1987, but most economists regarded privatizing a shared monopoly as a mistake. Over the past decade, the government rectified the mistake by requiring BAA plc to divest Gatwick and Stansted; the three airports now compete for airlines and passengers. Currently, Gatwick and Heathrow are each making a strong public case for a runway addition. The CAPA Centre for Aviation released a thoughtful report on the New York airports in 2015, recommending the competitive divestiture model as a key to revitalization.[7]

An airport's organizational form matters. A largescale empirical study in 2008 used a database of 109 international airports, with six different ownership forms: city/state government, airport authority, private shareholders, public-sector corporations, port authorities, or mixed ownership. The most productive airports were those that had been privatized, corporatized, or were under airport authority ownership. The least productive were those of U.S. port authorities.[8]

This fact could well be due to the practice of multipurpose port authorities using airport revenues to cross-subsidize other activities, rather than focusing on investing productively in their major airports.

In 2011, a major study from the Regional Plan Association (RPA) showed that, contrary to conventional wisdom, it would be physically feasible to add runway capacity at Kennedy and Newark Airports.[9] The study also showed that the benefits of adding new runways would be worth the cost, since air travel is so crucial to the continued economic growth of the region. Planning along these lines should have been initiated and brought to fruition by the Port Authority itself.

The RPA report was pathbreaking but unfortunately gave short shrift to the benefits of serious runway pricing at the PA's three major airports. Charging what amounts to market-clearing prices to land and to take off—instead of traditional landing-only fees based on aircraft weight—would generate significant new revenue to pay for additional runways and encourage airlines to increase their average aircraft size to allow for more passengers.

London's Heathrow and Gatwick, now privately owned, have abandoned traditional weight-based landing charges. Heathrow charges the same landing fee for any size aircraft, giving airlines an incentive to use larger planes, on average, to spread the cost over more passengers. The fees vary by time of day, with rates about twice as high during noise-sensitive nighttime hours, as compared with days and evenings. Heathrow also charges different landing fees based on their noise category, with rates six times higher for the noisiest planes than for the quietest.[10] Gatwick charges the same rate regardless of aircraft size or weight and likewise charges based on noise category. Unlike Heathrow, it charges for both landings and takeoffs, and with far lower rates off-peak than for peak-time operations.[11]

The Reason Foundation laid out a detailed approach to runway pricing for JFK, LaGuardia, and Newark Airports in 2007.[12] Incumbent airlines serving the three airports strongly opposed the report's recommendations to charge time-of-day rates for both landings and takeoffs, arguing, on the one hand, that pricing would not work. On the other hand, the incumbent carriers argued that if it did work, it would jeopardize their existing investments in terminal facilities (if new entrants were willing to pay more to use the runways than the incumbents).

The U.S. Department of Transportation (DOT) had long prohibited market-based runway pricing, allowing only traditional weight-based fees for landing. In 2008, the DOT lifted the ban, and the policy change survived legal challenges by the airlines. Thus, the PA has had the legal authority to implement runway pricing along these lines for nearly a decade but failed to use it.

After privatization, BAA plc—on its initiative—designed, financed, built, and now operates a nonstop heavy-rail transit line between its Heathrow Airport terminals and the Paddington Station in central London. Trains run every 15 minutes and make the trip in the same amount of time. BAA plc spent "over £500 million" ($646 million) to develop Heathrow Express and has stated that the operation is profitable. The round-trip fare is £36 ($46.50).13 Gatwick also has nonstop rail service via Gatwick Express, serving Victoria Station in central London. Trips depart every 15 minutes and take 30 minutes. The round-trip fare is £35.14 The Port Authority has failed to plan or build any kind of fast rail link to the airports for which it is responsible.

Bridges and Tunnels

In its generally forward-looking report, the PA's Special Panel unfortunately took for granted that the agency's bridges and tunnels are cash cows, always available for milking. Yet bridges and tunnels do not last forever. With proper maintenance, major bridges and tunnels can last up to a century. But in a growing metro area, they may become functionally obsolete decades before that.

Here are the in-service dates of the PA's revenue-generating bridges and tunnels: Holland Tunnel, 1927; Outerbridge Crossing and Goethals Bridge, 1928; George Washington Bridge and Bayonne Bridge, 1931; and Lincoln Tunnel, 1937. The Lincoln Tunnel added a third tube in 1957, and the G. W. Bridge's second deck opened in 1962. Since then, the PA has added no trans-Hudson capacity for buses, cars, or trucks.

The PA is building a replacement, with additional lane capacity, for the aging and inadequate Goethals Bridge (which connects Elizabeth, New Jersey, to Staten Island, New York), under a long-term public- private partnership. And the Bayonne Bridge (connecting Bayonne, New Jersey, to Staten Island) is being raised to provide increased clearance

for large cargo ships. Yet there are no other known PA plans for "revitalizing its core [highway] transportation assets."15 Given the overwhelming congestion on the Authority's other bridges and tunnels, the drivers who use them are clearly being shortchanged, paying ever-higher tolls for declining levels of service.

Congestion extracts a high cost from the highway, bridge, and tunnel users in the New York metro area. The Texas A&M Transportation Institute's "2015 Urban Mobility Scorecard" shows that the total annual cost of traffic congestion (measured only as the value of lost time and extra fuel consumed) in the New York metropolitan area increased from $10.2 billion per year in 1982 to $14.7 billion in 2014 (both in 2014 dollars). The New York metro area moved from being ranked second-worst to worst in the nation on this measure. On an individual basis, the average annual cost, $1,209 per commuter in 1982, had climbed in real terms to $1,739 in 2014. On a cost measure, New York has gone from the fifth-worst metro area in the nation to the second-worst.[16]

Manhattan residents may well be concerned that adding to trans-Hudson highway capacity will make congestion on the city's streets even worse. Not necessarily.

First, given that 85% of the containers going to and from the ports are carried by trucks (since they are going to or from nearby distribution centers and businesses), new truck-only capacity could relieve some of the congestion on current bridges and tunnels. Second, some portion of trans-Hudson vehicle traffic is longer-distance through traffic, especially on the G. W. Bridge, which is part of the East Coast's main north–south interstate highway (I-95). Third, additional bridge or tunnel capacity should be accompanied by congestion pricing for all of the PA's tolled facilities. And this pricing could be revenue- neutral, with higher rates during peak periods offset by lower rates during off-peak hours.

Unsurprisingly, the New York metro region's toll payers object to paying ever-higher tolls for ever- worse congestion. In a 1989 lawsuit, the Automobile Club of New York and New Jersey argued that it was not "just and reasonable" for the PA to include PATH losses in the rate base for determining tolls on the bridges and tunnels. A federal district court rejected the argument. And in a 2016 lawsuit, the Automobile Club of New York and New Jersey sued the PA (same as before), but this suit also failed. Any serious reform of the Port Authority should reconsider its long-standing policy of treating its bridge and tunnel customers as cash cows.

Bus Terminals

The PA includes the Port Authority Bus Terminal, or PABT, and the George Washington Bridge Bus Terminal in its "Interstate Transportation Network." Reporting the financials of the bus terminals separately would foster greater transparency and accountability. PABT, which opened in 1950, is the largest bus terminal in the U.S., thanks to expansions in the 1970s and 1980s. It serves both intercity and commuter bus operators, with the latter accounting for 85% of its operations. Despite strong growth in traffic during the past decade, its annual operating loss is growing—$97.6 million in 2014 alone. The Special Panel report ranked PABT low on alignment with performance objectives (presumably because of increasing losses) but high on alignment with the PA's core mission. The facility is in poor condition, and the report calls it "physically and functionally obsolete."

In October 2015, the PA's commissioners voted unanimously to begin work toward replacing PABT with an all-new facility. Following an international design competition, the PA staff will develop the plans, which tentatively call for building the new facility at an estimated cost of $7.5 billion–$10.5 billion. Without the huge potential fund transfer from bridge and tunnel revenue, such a grandiose plan would be highly unlikely. Instead of a competition to design the grandest edifice, it would make much better sense to invite conceptual proposals from potential developers/ operators whose plans would be judged on how self-financing they could be.

The G. W. Bridge Bus Terminal is a much smaller facility, poorly connected to Manhattan transit lines and with a small fraction of the daily usage of PABT. It is difficult to find, in the PA reports, either cost figures or recent usage figures, since this bus terminal is lumped in with the G. W. Bridge in financial statements. The PA reportedly considered closing or selling the G. W. Bridge Bus Terminal in 1990.[17] That might still make sense, given that the Special Panel report ranked it much lower in alignment with core mission than PABT.

PATH

Table 1 compares the key metrics of America's 10 largest heavy-rail transit systems, including PATH. Not only does PATH have the second-highest train (vehicle) operating cost per trip (1.9 times the median) and the third-highest total operating cost per trip ($3.90), but its general administration costs are the highest of all 10—at $0.92 per trip, they are 2.2 times the median of $0.42 per trip. According to New York's CBC, the annual PATH deficit rose from $294 million in 2004 to $383 million in 2014. The commission projects that PATH's annual loss will increase to $487 million by 2018.[18]

The CBC and the Special Panel noted that PATH's fares are relatively low, especially given that its ridership is somewhat more affluent than typical transit commuters. Despite several fare increases, the average one-way fare paid is just $1.96, due to an array of discount pass options. PATH grossly undercharges for what amounts to a high level of service between New York and New Jersey **(see the sidebar)**.

Why are PATH fares so low? While political pressures to keep transit fares far below cost affect all transit agencies, one factor unique to PATH is its heavy reliance on cross-subsidies from toll payers. The CBC noted that PATH is the only one of the 10 major heavy-rail systems that does not receive annual taxpayer subsidies from federal (Federal Transit Administration), state, and local taxpayer sources. The Special Panel recommended that the PA seek a

TABLE 1.

Key Metrics for the Largest 10 U.S. Heavy-Rail Systems, 2014

Agency	City	Op. Exp. (mil)	Unlinked Trips	Veh. Op. Cost	Veh. Maint. Cost	Non-Veh. Maint.	Gen. Admin.	Total Cost/Trip
NYC Transit	New York	$3,744	2,570	$0.67	$0.25	$0.38	$0.17	$1.47
WMATA	Washington	$844	285	$0.98	$0.59	$0.83	$0.56	$2.96
CTA	Chicago	$515	231	$0.88	$0.39	$0.62	$0.33	$2.22
BART	San Francisco	$489	119	$1.85	$0.80	$0.76	$0.70	$4.11
PATH	**NY/NJ**	**$312**	**80**	**$1.79**	**$0.39**	**$0.80**	**$0.92**	**$3.90**
MBTA	Boston	$309	167	$0.81	$0.31	$0.49	$0.24	$1.85
SEPTA	Philadelphia	$184	103	$0.88	$0.33	$0.34	$0.24	$1.79
MARTA	Atlanta	$178	73	$0.86	$0.42	$0.60	$0.57	$2.45
LACMTA	Los Angeles	$106	48	$0.99	$0.41	$0.61	$0.20	$2.21
Miami-Dade Transit	Miami	$76	19	$1.50	$0.93	$1.15	$0.50	$4.08
Average		$676	370	$1.12	$0.48	$0.66	$0.44	$2.70
Median		$311	111	$0.93	$0.40	$0.62	$0.42	$2.34

Source: Citizens Budget Commission, PATH report, Table A-1

Peak-Period Charge for Trans-Hudson Crossings (as of 2014)

PATH	$1.96
NJ Transit (train)	$5.00
NJ Transit (bus)	$5.50
Car toll (one-way, E-ZPass)	$6.25

Source: Citizens Budget Commission, "Financing PATH"

new operator for PATH, public or private—potentially one not regulated by the Federal Railroad Administration (FRA), whose regulatory requirements are more costly to meet than those of the Federal Transit Administration (FTA). It also recommended that PATH pursue federal funding from the FTA, as all other heavy-rail systems receive; reduce PATH's 24/7 service modestly; and increase advertising revenue.

CBC, however, suggested a major reduction in the cross-subsidy from toll payers (down from the current 69% of PATH's budget, to 25%–33%). "The large cross-subsidy PATH requires from more profitable lines of business," the CBC noted, "represents lost opportunities for investments in the agency's more profitable activities and an inequitable burden on users of the bridges and tunnels."

That would require either local sales taxes in the counties in which PATH operates or a special property tax in those same counties. While either change might be politically difficult, the change would be a marked improvement in fairness, better matching PATH costs to its beneficiaries. The commission recommended fare increases and revisions in the fare structure that could include peak/off-peak pricing and distance-based fares, both of which are used on some of the other large heavyrail systems. It also suggested transferring PATH to New Jersey Transit, which would presumably eliminate the FRA regulation and open the door to annual FTA grants.

Seaports

The Port of New York and New Jersey is the country's third-largest port, after Los Angeles and Long Beach. Like many U.S. port authorities, the PA operates largely as a landlord, leasing individual terminals to various private-sector companies.

The PA has invested heavily to prepare its facilities for the much larger post-Panamax cargo ships that will be able to use the expanded Panama Canal. The competition among East Coast ports to capture market share from new all-water service from Asia via the Panama Canal—as a faster alternative than shipping via the Suez Canal—is intense. However, there is considerable speculation within the shipping industry that more capacity is being created than will be used, given that ultra-large ships will likely stop at fewer ports. To capture the new business, ports will need greater depth and larger cranes but also a quicker and more efficient means of loading and unloading cargo. These improvements will be a challenge for the PA's facilities and workforces.

The *Journal of Commerce* has developed a ranking system for container ports that measures berth productivity (an index based on the average number of container moves per crane, per hour, while a ship is at berth).[19] **Table 2** lists the productivity scores for the world's 26 largest container ports. U.S. ports fare poorly compared with Asian ports. The most productive U.S. container ports are Long Beach and Los Angeles, with the New York–New Jersey ports a distant third, closely followed by Baltimore and Savannah. Panama's Balboa port is significantly more productive than any U.S. port and might develop a transshipment capability under which mega-ships from Asia would offload their containers for further shipment to the U.S. East Coast by smaller vessels.

By and large, PA port facilities are poor financial performers. The PA's 2014 annual report reveals net operating losses for Port Newark ($43.6 million, 54% of gross income); Howland Hook ($17.3 million, 159% of gross income); Brooklyn Marine Terminal ($7.6 million, 177% of gross income); Red Hook ($6.0 million, 405% of gross income); and Port Jersey Marine Terminal ($5.4 million, 24% of gross income).

These losses, once again, demonstrate the perverse effects of subsidizing potentially money-losing operations out of surplus revenues extracted from toll payers. The Elizabeth Marine Terminal generated enough net income—$71.6 million in 2014—to reduce the overall port commerce line of business net operating loss to $10.4 million. But with the pressing need for capital investments to modernize its port facilities and keep them competitive, the PA cannot afford to operate America's third-largest port system at

a loss.

There is a project under way to raise the clearance height of the Bayonne Bridge to accommodate larger, higher cargo ships. It will cost $1.3 billion, and the funds are coming from increased bridge and tunnel tolls. *Toll Roads News* has sharply criticized the equity of this arrangement:

Since the drive to heighten the shipping clearance at the Bayonne Bridge comes from shippers who will benefit by the ability to use larger ships, why won't they pay "tolls" to travel under the rebuilt bridge and help pay for what benefits them? Truckers and other motorists get a slightly widened deck, but otherwise the main change they'll see is a longer, higher climb and more fuel consumed.[21]

The Port of Hong Kong provides a cautionary tale for New York. Once one of the leading ports in Asia, Hong Kong is no longer among the world's 26 most efficient container ports (it is still fifth in container *volume*). A recent article in the *Wall Street Journal* attributed the decline to the port's "crowded terminals" and the ability of other Chinese ports to unload cargo containers faster and cheaper.[22]

World Trade Center and Other Real-Estate Ventures

The original World Trade Center development, though controversial at the time, ended up providing a return on the PA's original investment. Indeed, the agency leased it (in July 2001) for 99 years to developer Larry Silverstein, at a price of $3.2 billion. Following the destruction of the buildings on September 11, 2001, both Silverstein and the PA understandably committed to building a replacement World Trade Center on the site, with the PA focused in particular on creating a much better transportation hub to link PATH with subway lines and other transportation services. Unfortunately, for many reasons, the overall redevelopment suffered large cost overruns and schedule delays before its completion in January 2016.

In hindsight, the 1962 agreement that led the PA to build the original World Trade Center destabilized the agency and led to its current modus operandi: repeatedly increasing bridge and tunnel toll rates to finance money-losing and "zero-return" projects favored by the governors of New York and New Jersey. The first of these, of course, was the money-losing PATH system, which the PA agreed to take on in exchange for permission to develop the WTC.

As the Rudin Center report noted, "Between 2002 and 2012, the Port Authority spent more than $800 million on these 'regional projects,' including $1.8 billion for rehabilitation of New Jersey state highways and bridges, including the Pulaski Skyway."

The availability of cross-subsidies, the Rudin Center report concluded, "has seriously distorted the Port Authority's investment priorities."[23]

One consequence of the relentless increase in toll rates is the ongoing litigation brought in federal district court by the Automobile Clubs of New York and New Jersey, affiliates of the national AAA. The suit argues that the toll increases begun in 2011 violate the federal Bridge Act, since that legislation does not allow bistate toll revenues to be used for non-transportation purposes—or for transportation projects that don't link the two states in question (the Pulaski Skyway).

The U.S. Magistrate's Court for the Southern District of New York denied the auto clubs' request for an injunction to halt the toll increases but allowed the case to proceed, since these questions had not been definitively adjudicated in previous cases.[24] Should the plaintiffs prevail, it seems unlikely that the recent toll increases would be rescinded (due to bond covenants), but such a decision would significantly change the PA's continued reliance on toll facilities as its cash cow for cross-subsidies—at least for non-transportation projects.

The PA's Special Panel has recommended that the agency phase out its commercial real-estate holdings and, as well, "Repurpose, redevelop, or sell underperforming assets, including obsolete facilities such as the Red Hook Container Terminal." Managing its various non-transportation assets, the Special Panel noted, may "divert staff attention and financial resources from core transportation facilities and needed new projects."[25]

TABLE 2.

2013 Global Port Productivity

Port	Country	Productivity Score
Tianjin	China	130
Qingdao	China	126
Ningbo	China	120
Jebel Ali	United Arab Emirates	119
Khor al Fakkan	United Arab Emirates	119
Yokohama	Japan	108
Yantian	China	106
Xiamen	China	106
Busan	South Korea	105
Nansha	China	104
Shanghai	China	104
Dalian	China	104
Balboa	Panama	91
Salalah	Oman	91
Long Beach	United States	88
Los Angeles	United States	87
Bremerhaven	Germany	86
Mina Khalifa	United Arab Emirates	86
Rotterdam	Netherlands	86
Southampton	United Kingdom	81
Hamburg	Germany	81
New York–New Jersey	**United States**	**78**
Algeciras	Spain	76
Baltimore	United States	75
Prince Rupert	Canada	72
Savannah	United States	72

Source: JOC Group Inc.: Port Productivity Data[20]

4 FEASIBILITY

The reports from the CBC, the Rudin Center, and the PA's own Special Panel all suggest, to varying degrees, that the PA's business model of the last 50 years or so is no longer sustainable. But all three remain comfortable with the Progressive-era model of a public authority that master-plans the region's key transportation infrastructure as a system, owns and operates the major facilities, and dispenses extensive cross-subsidies (though perhaps no longer to non-transportation projects).

I would suggest, instead, a more sweeping reform based on three core ideas: 1) competition rather than monopoly among individual facilities; 2) revenue self-sufficiency for the major-mode facilities—airports, bridges and tunnels, and seaports; and 3) procurement and operation of facilities via long-term public-private partnerships (P3s), whose incentive is to earn a rate of return by providing high-quality service to paying customers.

The new business model draws on global best practices. These include a new appreciation for the benefits of competition among facilities (e.g., the now-competing London airports and the separately managed urban tollways of Santiago, Chile); privatization of major airports, seaports, and toll roads and development of new facilities via longterm P3 concessions; and increasing roles for variable pricing of airport runways and congested urban toll facilities.

The transition would have to take place over many years (more on this below), but the Port Authority would undergo a profound change. It would no longer be the owner and operator of major infrastructures. Instead, it would become the policymaker and regulator of facilities that would be developed or redeveloped via private capital under long-term P3 concession agreements. The PA would retain its responsibility for bistate transportation infrastructure, but as a growing number of state DOTs are now doing for megaprojects, it would rely on the competitive procurement of privately financed concession companies to build or modernize major airport, bridge and tunnel, and seaport facilities.

Once cross-subsidies end, the PA would use toll revenues to reconstruct and modernize the existing bridges and tunnels. The agency might also be able to finance new bridge and tunnel facilities for freight as well as motor vehicles. The PA could use airport revenues and new pricing schemes to add new runways to Kennedy and Newark Airports, as well as modernize airport terminals. There would also be a strong, even overwhelming, incentive to close down uncompetitive ports and to reinvest in competitive ones that could retain and expand the ports' market share among East Coast ports.

What about PATH and PABT? To improve PATH's finances, the alternatives reviewed earlier in this paper would all be worth implementing: significant fare increases to levels competitive with other means of crossing the Hudson; changes in the fare structure, such as peak/off-peak and distance-based rates; and eliminating 24/7 service.

PATH itself could be divested to New Jersey Transit, as suggested by the CBC. Another alternative would be to include PATH (or, at least, its new World Trade Center terminal) as part of the divestiture of the WTC.

There is nothing revolutionary in this recommendation. For example, Hong Kong's Mass Transit Railway Corporation (MTR) was created in 1975 as a government- owned corporation, and it is self-supporting from fares and real-estate revenue. The Hong Kong government partially privatized MTR in 2000, selling 23% of its shares on the stock market.

Whichever ownership alternative is selected, the CBC recommendation of changing PATH's subsidy from toll payers to federal and local taxpayers has much to recommend it. Today, there is no good reason to exclude PATH from the FTA's annual grant funding for other heavy-rail transit systems. There are also grounds for considering taxation of properties directly served by PATH's commuter trains (these properties benefit from their proximity to commuter transportation). Today, with apparently endless cross-subsidies from 17 toll payers, there is little political incentive to think about this. If the subsidies end, the incentives would be dramatically different.

The aging and obsolete PABT needs replacement. The money to make this happen could come from a public- private partnership that would develop PA-owned real estate in the vicinity. Navigant's *Phase II Report*[26] cited property around the terminus of the Lincoln Tunnel (Dyer Avenue) that "offers the potential opportunity for value-added real estate development that could generate hundreds of millions of dollars over a 10- to 15-year period." Navigant also noted that air rights above PABT North Wing present another development opportunity.

What Are Port Authority Assets Worth?

British prime minister Margaret Thatcher privatized the state-owned British Airports Authority (BAA), British Ports, British Rail, British Gas, British Telecom, and the formerly state-owned water and electric utility industries in the 1980s. In subsequent decades, there has been a worldwide trend toward privatization and public-private partnerships for large-scale infrastructure in transportation, energy, and environmental facilities.

In transportation infrastructure, specifically, the predominant model is not an outright sale (as with BAA) but rather a long-term lease under what is called a concession agreement—a form of public-private partnership (P3). Those agreements are the means by which the public-sector agency exercises governance and oversight of the concession company responsible for designing, financing, constructing (or reconstructing), operating, and maintaining the facil-

ity over a lease term long enough to generate a return on its investment.

New York's Port Authority has done a handful of such P3 deals, including the JFK Terminal 4 project in 1999, the current project to replace the Central Terminal at LaGuardia, and a concession for replacing the Goethals Bridge. Notable projects in other locales include the long-term concessions for modernizing the Indiana Toll Road and Chicago Skyway; concession projects to add express toll lanes to congested freeways in Orange County (California), Fort Lauderdale, Dallas and Fort Worth, and the I-495 Beltway and I-95 in northern Virginia near Washington, D.C.; and Puerto Rico's longterm lease to upgrade and modernize the San Juan Airport. Since 2003, more than $31 billion in equity and long-term debt has been invested in P3 infrastructure projects in the highway sector alone.[27]

There is, in fact, a global infrastructure investment-fund industry that includes major investment banks, sovereign wealth funds, and large public pension funds. In 2014, such funds raised a record $55 billion. They raised another $48 billion in 2015, via 77 funds.[28]

Some of the largest U.S.-based infrastructure funds include ArcLight Capital Partners, Global Infrastructure Partners, the Blackstone Group, and Goldman Sachs Infrastructure. Major U.S. pension funds that are investing directly in infrastructure include CalPERS (California Public Employees' Retirement System), CalSTRS (California State Teachers' Retirement System), the New York City Employees' Retirement System, the State Board of Administration of Florida, and the Illinois State Board of Investment. The nonprofit TIAA (Teachers Insurance and Annuity Association) is another direct investor.

Because long-term P3 concessions worldwide are modernizing airports, toll facilities, and seaports, we can gain a general idea of what the PA's existing facilities might be worth. Investors evaluate the value of a company or an infrastructure enterprise in terms of its earnings before interest expense, taxes, depreciation, and amortization (EBITDA). In the case of assets owned by the PA, taxes are zero, and the other figures are in its financial statements. Investors typically pay some multiple of EBITDA, either for outright ownership or a lease term long enough to have many of the attributes of ownership (e.g., 40–75 years).

Airports: Macquarie Capital has assembled figures that cover 30 commercial airport transactions for 2008–13. While the range of the EBITDA multiples ranged from a low of 10 times EBITDA (10X) to a high of 35X, the average was 16.3X.[29] The EBITDA multiple for the recent sale of London City Airport for $3.05 billion was 28X.[30] Attorney John Schmidt of Mayer Brown, who has advised on many P3 concession transactions, suggests that the high end of this range would apply to the PA's major airports.[31]

Toll facilities: Another Macquarie data set tracks 10 major toll-facility concessions from 2008 through 2015. These range from 18.3X to 35.5X EBITDA, with an average of 26.2X.[32]

Seaports: Although there have been some long-term port leases (and some sales), data on EBITDA multiples are harder to obtain. Port values declined sharply during the Great Recession and an accompanying slowdown in global shipping, but recent Australian port deals, according to *Infrastructure Investor,* were in the 25X–27X range.[33] Because most U.S. landlord ports (like the PA's) already have long-term leases with terminal operators, the high end of the EBITDA range is probably not realistic. To be conservative, the estimates that follow use 19X for baseline port valuation, with a high-end value of 26X and a low-end value of 12X.

Table 3 estimates the value of the PA's individual bridges and tunnels, airports, and port commerce lines of business. Figures for net income, interest, and depreciation and amortization are from Schedule E of the

PA's 2014 annual report. (For the three major airports, the PA's $233 million in 2014 Passenger Facility Fee [PFC] revenue was added to the reported net income figure, allocated among the three airports, based on relative passenger numbers.) The first set of valuation estimates uses the high-end multiples noted above; the second set uses the average multiple in each case, and the third set uses the low-end multiple.

The potential market values for the three sets of assets are summarized in **Table 4**, for the three alternative valuation multiples.

The PA reports the book value of all its assets as $30.77 billion (Schedule F in the 2014 annual report). Of course, book value includes investments in loss-producing facilities, which might have a market value of zero or less. The estimated market value of just the revenue- producing bridges and tunnels, airports, and seaports ranges from $78 billion at the highest EBITDA multiples to $32 billion at the lowest, more conservative, multiples.

Another interesting comparison is the assets' market value compared with the PA's outstanding bonds. Schedule D-2 of the 2014 annual report lists these:

Consolidated bonds	$19.23 billion
Special-project bonds	1.53 billion
T4 Liberty bonds	1.22 billion
Total bonds	**$21.98 billion**

The total indebtedness is considerably less than the market value of the revenue-producing assets.

5 REINVENTING THE PORT AUTHORITY

Since there would likely be strong political resistance to the sweeping change outlined above, two basic questions need to be answered. First, would the benefits to users of the PA's facilities and the economy of the

TABLE 3.

Estimated Asset Values of PANYNJ Bridges, Tunnels, Airports, and Seaports

Category	Asset	Net income	Interest	Deprec. & Amortiz.	Total EBITDA	High Multiple	High Estimate	Med. Multiple	Med. Estimate	Low Multiple	Low Estimate
Bridges & Tunnels											
	G. W. Bridge	$492,235	$23,523	$32,007	$547,765	35.5	$19,445,658	26.2	$14,351,443	18.3	$10,024,100
	Holland Tunnel	$65,745	$7,590	$26,601	$99,936	35.5	$3,547,728	26.2	$2,618,323	18.3	$1,828,829
	Lincoln Tunnel	$82,612	$19,021	$43,611	$145,244	35.5	$5,156,162	26.2	$3,805,393	18.3	$2,657,965
	Bayonne Bridge	$3,831	$6,455	$5,186	$15,472	35.5	$549,256	26.2	$405,366	18.3	$283,138
	Goethals Bridge	$106,589	$7,089	$34,879	$148,557	35.5	$5,273,774	26.2	$3,892,193	18.3	$2,718,593
	Outerbridge Crossing	$112,976	$1,843	$5,048	$119,867	35.5	$4,255,279	26.2	$3,140,515	18.3	$2,193,566
	Total B&T						$38,227,856		$28,213,234		$19,706,190
Airports											
	LaGuardia	$30,603	$19,884	$48,927	$99,414	35.0	$3,479,490	16.3	$1,620,448	10.0	$994,140
	Kennedy	$242,303	$64,092	$141,945	$448,340	35.0	$15,691,900	16.3	$7,307,942	10.0	$4,483,400
	Newark	$278,895	$57,617	$114,148	$450,660	35.0	$15,773,100	16.3	$7,345,758	10.0	$4,506,600
	Teterboro	-$4,147	$8,149	$15,668	$19,670	35.0	$688,450	16.3	$320,621	10.0	$196,700
	Stewart	-$13,244	$1,040	$1,260	-$10,944	35.0	-$383,040	16.3	-$178,387	10.0	-$109,440
	Total Airports						$35,249,900		$16,416,382		$10,071,400
Port Commerce											
	Newark	-$43,615	$33,277	$29,129	$18,791	26.0	$488,566	19.0	$357,029	12.0	$225,492
	Elizabeth	$71,613	$36,445	$36,474	$144,532	26.0	$3,757,832	19.0	$2,746,108	12.0	$1,734,384
	Brooklyn	-$7,552	$1,211	$1,016	-$5,325	26.0	-$138,450	19.0	-$101,175	12.0	-$63,900
	Red Hook	-$5,979	$0	$0	-$5,979	26.0	-$155,454	19.0	-$113,601	12.0	-$71,748
	Howland Hook	-$17,258	$14,603	$17,023	$14,368	26.0	$373,568	19.0	$272,992	12.0	$172,416
	Greenville	$475	-$69	$341	$747	26.0	$19,422	19.0	$14,193	12.0	$8,964
	Port Jersey	-$5,413	$7,899	$2,292	$4,778	26.0	$124,228	19.0	$90,782	12.0	$57,336
	Total Ports						$4,469,712		$3,266,328		$2,062,944

Source: Author's calculations based on PANYNJ 2014 annual report financial data

TABLE 4.

Summary of Estimated Range of Market Values, in Billions

	High-End	Average	Low-End
Airports	$35.2	$16.4	$10.1
Bridges & Tunnels	$38.2	$28.2	$19.7
Seaports	$4.5	$3.3	$2.1
TOTAL	$77.9	$47.9	$31.9

Source: Table 3

metro area be significant enough to warrant sweeping change? Second, is such change even possible, given the constraints imposed by the Port Authority's bonded debt? Since the first question is irrelevant unless the answer to the second question is yes, the financing question must be addressed first.

Financing

The PA does not issue airport revenue bonds to finance airport capital projects, toll revenue bonds for bridge and tunnel projects, and port revenue bonds for port projects. Instead, the agency's long-standing practice has been to issue consolidated revenue bonds. The PA's revenue streams back the debts, and the agency's board determines how it uses the funds raised. The financial statements, in other words, do not reveal which bond issues financed which facilities.

The PA board may allocate debt service among the lines of business, but that does not reflect any actual link between a facility's source of capital and what it is required to pay in annual debt service. Bond markets accept this practice because robust cash flows from toll revenues (and historically, also from airports) have been enough to rate the debt as investment- grade. But this practice also makes it hard for investors, customers, and citizens to see how the PA actually conducts its business.

The PA's Special Panel recognized that changes to the agency's 1952 Consolidated Bond Resolution would be necessary to divest the agency's noncore assets.[34] The bond resolutions of most other public agencies, it noted, "typically have a defeasance provision allowing the borrower to void the debt when they set aside escrow funds sufficient to service that advance-refunded debt." Many bonds do not allow the issuer to pay them off early, for example, if interest rates have decreased and the issuer could save money by refinancing at a lower interest rate. But many bonds do permit the agency to refinance by "defeasing" the existing bonds. That means setting aside enough funds (often using very low-risk Treasury debt) to make the scheduled payments to the original bondholders.

The PA's Special Panel report calls for amendments to the agency's Consolidated Bond Resolution that would: (1) permit the sale of assets and the use of the sale proceeds; and (2) provide for the defeasance of debt. It notes that amendments can take effect only after the consent of 60% or more of the current bondholders has been obtained. The Special Panel suggests that this change could be phased in by including the new language in all new and refunding bond issues over the next five to six years. And "once the 60% threshold is reached, the amendments would apply to all out-

standing bonds."

Assuming that such a process takes place over the next five-to-six-year period, the PA could develop a long-range asset-restructuring plan to effect a transition to the model that I recommend in this report. The first phase would be to sell noncore real-estate and economic-development projects. Since those projects do not provide any net revenue for debt service, this might be doable before the 60% bondholder approval is reached. After achieving that threshold, the PA could bid out the various airport, bridge/tunnel, and seaport facilities in phases, comparable with the recent long-term P3 concessions for the Indiana Toll Road and the San Juan International Airport. In each case, the concessionaire pays up front for the lease, providing funds to defease a comparable amount of PA bonds.

This process would be fully consistent with the PA's Special Panel's recommendation to "[e]mploy public-private partnerships, tax increment financing, and other innovative financing tools to provide funding alternatives and enhanced operational opportunities."[35] In short, P3 agreements make it financially possible for the PA to gradually retire its consolidated bonds and divest its non-transportation and selected transportation assets. Cross subsidies would end, and the agency's finances would become far more transparent to the public.

Political Turbulence

Any proposal to end large-scale cross-subsidies from users of the airports and bridge/tunnel facilities would likely be opposed strongly by current recipients of those subsidies, including users of PABT, riders on PATH, and those employed at the money-losing ports. Other opponents include those who hope to use future cross-subsidies for major new projects such as new Amtrak tunnels beneath the Hudson River and a proposed Cross Harbor Freight Movement Project. The former project is now estimated to cost $24 billion,[36] while the latter, though still largely undefined, has been estimated at $7 billion–$11 billion, if the alternative chosen is a rail/ truck tunnel.[37]

Against this predictable howl of protests are the benefits to the region's economy. These benefits are potentially quite large because the PA's core transportation assets will all need large-scale investment in coming decades.

Kennedy and Newark Airports urgently require more runway capacity. Paying for these improvements can best be met via a combination of existing airport revenue (no longer diverted to money-losing, non-airport projects) and net new revenues from market-priced runway access (as implemented by privatized London Heathrow and Gatwick Airports in recent years). These changes will enable air transportation to increase *pari passu* with the region's economic growth.

Trans-Hudson surface transportation will need very significant investment as the existing bridges and tunnels reach the end of their design lives. Better trans-Hudson goods movement will likely require a new tunnel for freight, possibly a truck/bus tunnel linked with a Bay Ridge Truckway in Brooklyn.[38] Serious congestion pricing, with lower than current rates at nonpeak hours and higher rates during peak hours, could generate the same or increased toll revenue from the modernized tunnels while bringing about a meaningful reduction in peak-period congestion.

The PA's ports are entering a changed era of mega-ship ocean transport, in which they will be in serious competition with other East Coast deep-draft ports—such as Baltimore and Norfolk—for container traffic serving the Northeast and the Midwest. In a recent study, McKinsey proposed variable pricing by terminals to provide incentives for both vessel operators and terminal operators to load and unload more efficiently.[39]

These changes will revitalize the PA's core infrastructure, with each airport, bridge, tunnel, and port facility separately managed and held accountable for performance under the terms of its long-term concession agreement. First-rate transportation infrastructure of this sort is essential for continued economic growth. This agenda should win the support of the entire region's business community, as well as that of airport, highway, and seaport customers.

Nevertheless, the users of the PA facilities will be concerned that the high prices that P3 concessionaires pay for their leases mean big price increases for them. That has not been the experience elsewhere. The San Juan International Airport concession competition required the bidders to agree to a fiveyear freeze on airline charges, followed by increases limited to the rate of inflation. Those limitations are built in to the long-term lease/concession agreement enforced by the Puerto Rico Ports Authority.

Likewise, the Indiana Toll Road concession limits annual toll increases to an inflation index; when the IFM Investors Global Infrastructure Fund acquired the concession in 2015, it had to accept all the provisions of the original agreement. Companies engaging in these kinds of leases seek long-term returns via growing the customer base, realizing increased operating efficiencies, and generating increased discretionary revenue (such as expanded retail sales at airport terminals and tollway rest areas)—not by charging sky-high rates.

The PA has made modest use of P3 concessions, but the agency may encounter political pushback if it expands their number and scope. One way to overcome resistance is if public pension funds become investors.[40] Australian and Canadian pension funds have been the pioneers in large-scale infrastructure investment. For example, a consortium led by Canadian pension funds Borealis and the Ontario Teachers' Pension Plan submitted the winning bid for London City Airport in February 2016.[41]

Many U.S. public pension funds, grossly underfunded and faced with a critical need to increase their average rate of return on investments, have begun to allocate a portion of their portfolios to infrastructure in which they can make equity investments. Generally speaking, brand-new

toll roads or bridges (called "greenfield" projects) are considered too risky for pension funds. By contrast, P3 projects to manage and rebuild/modernize existing infrastructure are considered lower-risk and suitable for pension funds.

Two recent U.S. examples illustrate this trend. In 2015, the company that had won the long-term concession for the Chicago Skyway in 2004 put the remaining 89 years of the concession up for bid. A consortium of three Canadian public pension funds won the bid, paying $2.84 billion for the Skyway (which they will have to reconstruct at some point during the term of that concession). The lease for the much larger Indiana Toll Road was also put up for sale in 2015. The winning bidder, a consortium of Australian and U.S. pension funds—including the New York City Employees' Retirement System—paid $5.73 billion for the remaining 66 years of that concession. That toll road will also have to be reconstructed and widened during the term of the concession.

The PA could require that qualified teams invited to bid on airport, bridge/tunnel, and port projects include one or more public pension funds. Another factor for winning the bid might be a conservative debt-equity ratio, aimed at ensuring financially conservative bids. The debt/equity of the winning Skyway bid was 46/54, and that of the Indiana Toll Road was 43/57.

Public pension fund investment in infrastructure addresses two major problems: the need for increased investment in renewing aging infrastructure; and the pension funds' need to earn higher returns.[42]

6 CONCLUSION

The new model suggested in this paper draws on global best practices that have mobilized large sums of new capital investment: long-term public-private partnerships with dedicated revenue streams. This model recognizes that large-scale infrastructure facilities in a growing metro area need ongoing investment: to add capacity as needed, to renew and replace facilities, and to keep pace with the latest technology. The PA's role would change from being financier, owner, and operator of the infrastructure to that of planner and regulator of an array of concession companies held accountable for performance, not only via bond covenants but also by performance criteria embedded in their long-term concession agreements.

It will hardly be easy to reinvent the Port Authority, but the need to do so is increasingly urgent.

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THE LESSONS OF LONG-TERM PRIVATIZATIONS:

WHY CHICAGO GOT IT WRONG AND INDIANA GOT IT RIGHT

AARON M. RENN

Chicago's Parking-Meter Debacle: In 2004, Chicago leased its city-owned Chicago Skyway Toll Bridge for 99 years for $1.83 billion. The deal was considered a win. Hoping for another, the city leased several downtown parking garages in 2006 for 99 years, in return for a payment of $563 million. Chicago next turned to parking meters and Midway Airport. The city developed both these deals in 2007 and 2008. In September 2008, amid the U.S. financial crisis, the city announced its deal for privatizing Midway, which was promptly approved by the city council. The Midway deal ultimately fell apart, as the winning bidder failed to line up financing.

In December 2008, Chicago Parking Meters LLC, a Morgan Stanley–led investment group, won a 75-year concession to control and operate approximately 36,000 parking meters throughout Chicago in return for a $1.16 billion lump-sum payment. The lease required the company to install new multi-space kiosks for parking payments and to accept credit cards. The concessionaire also was empowered to write parking tickets, though Chicago retained the revenue. The city retained advertising and naming rights over the meters. Chicago also agreed to a non-compete clause that prohibited it from opening off-street parking lots that would compete with meters—unless the rates in the lot were at least three times those of the meter rate in the area. ***CONTINUED ON NEXT PAGE***

In a lopsided vote, the city council approved the lease on December 4, 2008. The deal closed in early 2009 but almost immediately ran into trouble. The company initially increased rates in the Loop, the core of Chicago's central business district, by a modest 17 percent (though parking rates would rise from $3.50 per hour in 2009 to $6.50 per hour in 2013). However, parking rates in other parts of the central business district doubled almost immediately and rose even higher elsewhere in the city.

The higher rates provoked outrage. Meters broke as they overflowed with quarters before the new credit card–reading kiosks were installed. Several parking meters were vandalized. The deal rapidly became a public-relations disaster for Mayor Richard M. Daley and his administration. The public's ire was further stoked when aldermen began complaining that they could no longer adjust parking policy in their wards because doing so would trigger hundreds of thousands of dollars in penalty payments.[3]

In June 2009, Chicago's independent inspector general issued a report claiming that the parking meters had been leased for only about half of what they were worth.[4] Even as city officials and others disputed the claim, public opinion turned solidly and irrevocably against the lease. By September, Mayor Daley's approval rating had fallen to 35 percent, and he ultimately decided not to run for reelection.[5]

The $1.16 billion payment that Chicago got for the lease was originally intended to be distributed to a variety of funds, including: $400 million to a long-term reserve (to generate revenue to replace the city's existing parking-meter revenue stream); $325 million to a midterm reserve; $326 million to a budget stabilization fund; and $100 million to a "human infrastructure" fund.6 Instead, the city nearly immediately started using the money to cover its budget deficits during the Great Recession, including spending most of the longterm reserve fund. By 2010, only $180 million was left.[7]

Rahm Emanuel took office in 2011 as a critic of the deal, joining virtually everyone else in the city. The new mayor battled with Chicago Parking Meters over compensation claims for out-of-service meters and free parking for the disabled. Ultimately, Mayor Emanuel amended the deal in 2013, which he claimed as a victory8 but others dismissed as a further giveaway. Either way, the amendment did not materially change the lease. To this day, Chicago's parking-meter lease is viewed as a civic debacle and is a source of lingering public anger.

Indiana's Toll-Road Lease

Mitch Daniels was elected governor of Indiana in 2004. During his campaign, he learned that the Indiana Department of Transportation's (INDOT) list of programmed projects vastly exceeded the state's financial resources.

After entering office, Daniels commissioned a study that revealed a $1.8 billion funding gap over the next decade. INDOT then developed a program, "Major Moves," that included only projects that could be paid for. The projects were selected via a scoring and public-input process. The result: many major projects were pushed off more than a decade and were de facto canceled.[9]

In the meantime, the Daniels administration investigated more than 30 potential ways to address the funding gap in its highway plan. Likely inspired by Chicago's successful Skyway lease, Indiana undertook to lease the Indiana East– West Toll Road, a 156-mile highway across the northern edge of the state.

The East–West Toll Road, like many others, was conceived and built in the pre-interstate era and was opened in 1956, the same year the Federal Aid Highway Act was enacted. Today, it's part of the interstate system as I-90. By 2005, it was a break-even operation and still carried $200 million in debt.

The East–West Toll Road flowed directly into the Chicago Skyway and was, in effect, the Skyway's only source and destination of traffic. This meant that it had leverage over the Skyway, which had recently increased tolls; unsurprisingly, the firms—led by Spanish infrastructure developer Cintra and Australia's Macquarie Bank—that led the consortium that won the Skyway lease also won the Indiana Toll Road lease.

The Indiana Toll Road Concession Co. paid the state a lump sum of $3.85 billion for a 75-year concession. The consortium was required to implement electronic tolling and invest in upgrading and widening portions of the toll road. And it had to maintain certain levels of service in rural and urban areas.

In return, the company could increase tolls—which it did, significantly. Tolls were raised 72 percent initially, with passenger-car tolls for an end-to-end ride increasing from $4.65 to $8.00. Rates also increased annually, for trucks, through 2010. Thereafter, rate increases for all vehicles were capped to the greater of three: 2 percent or the rate of inflation or the rate of increase in per-capita GDP. The deal also included a non-compete that prohibited the state from building a competing interstate highway.[10]

The lease deal was announced on January 23, 2006. Because of the amount of money involved and the projects it could finance, the Daniels administration expected widespread support for the deal. Instead, there was immediate, vociferous opposition:[11] from Democrats who wished to oppose the agenda of a Republican governor; from those who saw themselves as losers in the deal, including the trucking industry and residents in the counties through which the toll road passed, who would be paying the higher tolls (still, 66 percent of toll revenue came from out-of-state drivers); and from people concerned that foreign corporations were taking control of a state asset.

After a heated public debate, the deal was approved on a largely party-line vote. The consortium took over operations and implemented the required widening and electronic tolling. Indiana allocated the lease proceeds in a variety of ways, including: $200 million to retire existing toll-road debt; $240 million for local aid to the seven counties through which the toll road passed; $150 million in infrastructure

aid to all local governments in the state; $120 million to the Northwest Regional Development Authority; $500 million to a long-term reserve, the Next Generation Trust Fund; and the balance to financing the expanded Major Moves highway program. Projects included 413 miles of new highway—notably, the construction of the initial stages of a long-proposed I-69 extension from Indianapolis to Evansville. The state also rehabbed or replaced 1,190 bridges and 4,000 miles of pavement over a ten-year period.[12]

Traffic on the toll road fell short of Indiana Toll Road Concession Co.'s expectations, and, as a result, it filed for bankruptcy in 2014.[13] Australia's IFM Investors, backed by a group of pension funds, bought the concession, which exited bankruptcy in 2015.[14] There was no disruption in highway operations during bankruptcy.

Critics still snipe at the terms of the lease or complain that the state faced a funding shortfall at the end of the expiration of the Major Moves program. But many others, inside and outside Indiana, have generally assessed it as a good deal for the state.15 So what did Chicago get wrong with its parking-meter lease that Indiana got right with its toll-road lease?

1 LESSONS LEARNED

Public Review Matters

In Chicago, the Daley administration largely developed the parking-meter lease behind closed doors,[16] giving the city council only three days to vote on the deal after the mayor released its terms. After only one hour of debate, the council approved the lease by a 40 to 5 vote.[17] Among those who voted no was alderman Toni Preckwinkle, now president of the Cook County Board of Commissioners, who said that she did not have time to review the deal. That's not surprising: a scanned copy of the approval ordinance, which includes the text of the lease agreement, is 512 pages.[18]

The Daniels administration developed the Indiana Toll Road lease largely out of public sight, too. But public vetting of that lease was another matter. The Chicago city council, composed almost entirely of Democrats, had a history of approving Daley proposals rapidly, by lopsided margins. Though Daniels had a Republican majority in the Indiana General Assembly, he faced a large Democratic minority caucus who would fiercely contest any policy that he proposed.

This meant that the toll-road release had to go through a traditional legislative approval process, with hearings and significant media scrutiny. Daniels announced the deal on January 23, 2006.[19] It was later approved by the assembly, in a largely party-line vote, on March 14, 2006.[20]

The opposition was significant and well financed. The yes and no camps both ran ads in support of their positions. The Kokomo Tribune reported on the intensity of the debate:

The legislative battle over Gov. Mitch Daniels' "Major Moves" highway plan [including the toll-road lease] has almost surpassed the intensity of last year's fight over daylight-saving time, and has all the firepower of a high-stakes election campaign. Bitter, partisan shots not only fired by legislators but also their state political parties; television and radio ads; highly charged rhetoric; polls; staged rallies, and strong opinions conveyed by lots of average Hoosiers.[21]

The review period and debate gave opponents plenty of time to analyze the 112-page concession agreement[22] to identify troublesome provisions. No such provisions were identified, and the contract has functioned well since its approval.

While a longer vetting process does not necessarily mean that the final deal will be better, two important facts emerge from Chicago's ill-fated parking-meter lease:

- The rushed approval process created a public perception that the parking-meter deal was illegitimate, if not crooked. While many in Indiana disapproved of the toll-road deal, no one questions its legitimacy.
- Had there been a longer review and debate process over Chicago's parking-meter lease, the troublesome provisions of that deal may have been discovered before it was too late.

The lesson: governments undertaking privatization deals benefit from an adequate public review and comment period. Time is needed to explain these complex deals to the public and to ensure that they are properly vetted and seen as legitimate.

Carefully Manage the Transition from Public to Private Operation

Chicago's parking-meter lease significantly increased parking-meter rates and required the private company to install new multi-space kiosks that would accept credit cards. However, to maximize its revenue, Chicago Parking Meters reprogrammed the existing meters to higher rates before installing the new kiosks. People had to carry many more quarters—annoying enough. But there was more, as the Chicago Tribune reported:

City Hall is weathering a storm of controversy over failures in its $1.15 billion lease of all city parking meters.... But problems quickly surfaced. They ranged from poor preparation by LAZ to take over such a large meter system to the company's failure to repair broken meters and regularly empty the coin banks in the meters, which often filled up with quarters and jammed after meter rates quadrupled this year. On May 27, about 250 pay-and-display-boxes—many of them new devices recently installed—failed in the downtown area.[23]

The lesson: don't overlook the transition. The initial experience of a privatization deal will be difficult to overcome if it's a bad one.

Don't Blow the Up-Front Payment

As a general principle, one-time revenues should be used on one-time expenses, not on recurring ones. Indiana heeded that principle. The majority of the $3.85 billion that the state got from the lease financed Major Moves, Indiana's new road-construction program. Additionally, $500 million was put into a so-called Next Generation Trust Fund that would maintain additional road and bridge capacity over the long term. Some monies were distributed to localities for infrastructure projects, and some special funds were granted to counties through which the toll road passed.[24]

Unfortunately, Chicago used much of its $1.16 billion lease payment to cover the city's budget crisis.25 Less than two years after the deal, only $180 million of the meter money remained.[26] Meanwhile, the Daley administration put off financial reforms to address the city's structural financial problems— problems that continue to plague Chicago.

Watch Out for All the Budget Implications of Privatization

The Indiana Toll Road had been a break-even operation, so the lease payment was a pure windfall for the state. Chicago's parking meters, however, had contributed $16 million–$17 million in net revenue annually to the city's corporate fund.[27] That money would be lost: under the terms of the lease, the company was entitled to 100 percent of the meter revenue.

Chicago did plan to replenish its coffers from a Revenue Replacement Fund. This long-term reserve account initially received $400 million from the lease proceeds, and a city ordinance required annual transfers of $20 million to the city's corporate fund. But after significant drawdowns, including $210 million in 2010 for the city's budget deficit, the fund had only $122 million at the end of September 2015. As a result, the fund is now budgeted to contribute only $2.5 million annually to the city's corporate fund.[28]

This small but telling example of financial mismanagement also demonstrates how difficult it is for governments to avoid raiding the cookie jar. Indiana is not immune: the state has begun drawing from the balance of the Next Generation Trust Fund to finance current road construction.[29]

The lesson: governments should not impair future revenue streams in privatization transactions, and they should be skeptical of the long-term viability of revenue replacement reserve funds as a mitigation tool. At a minimum, privatization deals that affect an existing revenue stream should replenish that stream, with inflation adjustments in the form of future payments from the concessionaire.

Beware of Compensation Payments

Some privatization advocates[30] have defended Chicago's parking-meter lease while agreeing that its implementation was botched. But subtle financial pitfalls can make it difficult for a government to cope with even a well-managed privatization lease.

Compensation payments are one such pitfall. Because the concessionaires in both Indiana and Chicago paid large, onetime lump-sum payments to lease an asset, they needed reassurance that they could recover the money as well as earn the rate of return they anticipated. So the lease contracts have compensation clauses that protect these vendors against any adverse changes by the government.

Consider, for example, what would happen if Chicago passed an ordinance that lowered parking-meter rates in defiance of the lease. For protection, provisions in the lease require compensation if the city takes any such action that impairs the financial value of the meters. Similar provisions protect the lessee of the Indiana Toll Road. (Compensation terms do not protect against the loss of revenue if fewer people park or drive on a toll road; that is, part of the risk the lessee properly bears.)

In the case of the Indiana Toll Road, there has been only one event that required compensation.31 In 2008, the Borman Expressway, which runs parallel to the Indiana Toll Road for part of its length, flooded and was closed for about a week.[32] The state made the toll road free for that period as an alternate route—and it paid the Indiana Toll Road Concession Co. $500,000 to make up for lost revenue.[33]

The Chicago parking-meter lease requires the city to reimburse the concessionaire for free parking provided to the disabled, as well as for any meter closures—including road construction, street fairs, and special events—in excess of an annual closure allowance.

Unlike floods, the events triggering compensation in Chicago are not unusual; they occur regularly. And the compensation payments turned out to be far higher than anticipated.

Compensation payments for free disabled parking alone reached as much as $21 million per year. This prompted Illinois to change its law on disabled parking to restrict free parking to only those who are physically unable to use a parking kiosk. But this was still expected to result in $5 million in annual compensation payments.[34] (Initially, the Emanuel administration disputed the concessionaire's claims for compensation for meter closures. Yet after a negotiation, the administration projected that the city would pay compensation of $6.5 million per year.)[35]

So Chicago not only lost $16 million–$17 million in annual meter revenues that it received pre-lease; it also became burdened with an annual $11.5 million in compensation costs. The total annual revenue swing is now about $26 million per year over the 75-year life of the lease (assuming that the Revenue Replacement Fund continues to generate $2.5 million per year).

The lesson: governments should be highly skeptical of any privatization deal that involves regular, recurring compensation payments. Put another way, any public asset that requires recurring closures that might require compensation is a poor candidate for a long-term privatization lease.

2 THE LIMITS OF PRIVATIZATION: PUBLIC ASSETS AND PUBLIC POLICY

In the case of a highway, the state, a toll authority, or a private entity builds, constructs, and operates a tangible capital asset. That asset's construction, maintenance, and operations costs—as well as potential profits—are recovered through user charges. This is a simple-to-understand model similar to many private businesses. For this reason, some new toll projects are private concerns from the beginning.

Highways also have a characteristic known as "overdetermined form"—that is, it would be very difficult to repurpose them for anything else. The same is true of hospital buildings, which are very difficult to retrofit for other uses, except at great expense or by demolishing them and starting over. Overdetermined form holds for highways regardless of whether they are run publicly or privately.

There are crucial differences between a highway, an airport, a bridge, and a typical three-story building on Main Street. These differences help us understand which public assets are suitable for privatization. Consider the three-story building.

The ground level could have a retail outlet, a restaurant, or an office. The upper floors could be used for offices, a warehouse, or apartments. These buildings are more easily adapted for new uses.

Another characteristic of highways and toll roads sets them apart: they tend to be separated from the areas through which they pass—by definition, they are limited access. This is one reason many people do not like them, particularly in cities, because they can divide neighborhoods in two or otherwise create a difficult-to-cross barrier. Highways and toll roads are often criticized for visual and sonic blight, too.

The upshot of having these characteristics is that, after the decision is made to build them, highways and toll roads are only weakly related to other urban-planning considerations. Instead, the main policy considerations relate to the operations of the road itself, such as congestion.

These characteristics make highways and toll roads—and, by extension, similar public assets—good candidates for privatization lease: they are predictable, stable, and largely standalone. It's not likely, for example, that a state will want its road back in order to use it for a higher-value public good. Even if a state did want its road back, by its very nature, changing a toll road to something else would be very costly.

Of course, such public assets are not immune from risk. For example, who knows what driverless vehicles may mean for the Indiana Toll Road? But this risk is borne principally by the concessionaire. Given the history of changes in transportation technology, unforeseen developments will likely require contract modifications. Such circumstances would potentially enable the concessionaire to renegotiate the terms of the lease; yet such circumstances would also put the concessionaire at risk, giving the state leverage in a renegotiation. In any event, the risks associated with toll-road privatizations have so far proved manageable.

Parking meters are qualitatively different: Are they primarily a capital asset? Are they a government service, as traditionally understood? The answer to both questions is no. Parking meters are primarily an urban-planning tool that cities use to manage the utilization of precious on-street curb space for the benefit of the surrounding neighborhood. Only secondarily do parking meters represent economic rights to profit from public spaces.

In responding to the question, "Why does the city have parking meters?" Chicago says that "meters play a vital role in facilitating traffic management, promoting business, and reducing congestion and pollution."[36] Note the inclusion of promoting business as a key rationale for meters. Cities install parking meters because there is more demand for parking spots than there are spots to park in, particularly spots that are conveniently located adjacent to storefront businesses. Without some form of meter system or other time limits on parking, employees of nearby businesses (or others) might grab all the spots and make it difficult for would-be business patrons to find parking. Parking meters help ensure that storefront businesses have enough parking for customers.

Traditionally, technology limited parking meters to simple pricing schemes, such as 15 minutes for every quarter inserted, up to a maximum of two hours. Such pricing schemes were in effect at all times when meters were being enforced. Today, modern technology allows more dynamic pricing systems.

San Francisco recently implemented a system, SF Park, that varies parking-meter pricing by neighborhood and time of day to target 85 percent occupancy. The goal: to ensure that parking spots are well utilized and that a few spaces are always available for people who want a spot at the prevailing price. In other words, the goal is optimal occupancy, not revenue maximization or rate maximization. (One interesting result of the SF Park implementation is that the pilot zone's parking-meter rates actually declined by 4 percent, on average.)[37]

There is an additional complication with a parking-meter lease, or a lease with similar public assets. The city retains responsibility for maintaining the streets and sidewalks; only the meters and the right to collect money from them are privatized. The equivalent situation in the case of a toll road would be to privatize just the toll booths while the state retained all responsibility for the road.

What's more, unlike a toll road, the curbside asphalt on which people park is not an asset with overdetermined form. This real estate is more like a building on Main Street, easily and cheaply repurposed. For instance, San Francisco implemented a pop-up café concept in which parking spots became space for sidewalk cafés. Parking spots also could easily be turned into protected bike or bus

lanes, space for street vendors, or other uses. Even the street itself can be repurposed—as in New York City, when Broadway in Times Square and Herald Square was turned into a pedestrian plaza. (This was initially done very cheaply with paint and lawn chairs.)

What's in the best interest of a neighborhood may be very different as conditions change over years and decades—so the curbside could be repurposed, returned to use for parking, etc.

Unlike a toll road, parking spaces are intimately integrated with the functioning of a neighborhood. Parking spaces are a core part of the city's largest supply of public space—namely, its streets—and profoundly affect the adjacent properties. Parking spaces are intimately tied to neighborhood health.

Returning to the goal of promoting business, business conditions change over time in neighborhoods, so parking policy needs to respond accordingly. In summary, parking meters:

- Are primarily an urban-policy tool, not a capital asset
- Involve utilizing general-purpose, flexible real estate
- Are strongly connected to the surrounding areas
- Are strongly connected to other public-policy concerns
- Need to respond dynamically to changing neighborhood conditions and priorities

When a city like Chicago signs a long-term concession for parking meters, it is: 1) selling economic rights to its streets, treating parking meters as primarily a revenue source instead of an urban-planning tool; and 2) severely restricting its ability to change future public policy regarding its streets and neighborhoods. In other words, the city takes a particular public policy and freezes it in place for decades.

The lesson? Parking meters—as well as other general-purpose public assets integrated with neighborhood functioning and tightly bound to public policy—should not be subject to longterm privatizations. This rule should include long-term deals involving a significant amount of streets and sidewalks. Otherwise, a city will limit its ability to change public policy as circumstances change.

Technically, Chicago retains the right to do anything it wants with parking policy and the spots in question. However, as noted, changes can involve compensation to the concessionaire for lost revenues. To be sure, had Chicago retained control of the meters and then decided to remove them, it would still lose the revenues. But under the terms of its current lease, removing the meters now would be far more costly.

Roosevelt University's Stephanie Farmer conducted interviews with Chicago-area transportation planners about the effect of the parking-meter lease, and concluded: "New planning and fiscal risks work as obstacles for transportation planners altering current street-level transportation configurations."[38] This is not a theoretical risk. When Chicago alderman Scott Waguespack wanted to reduce meter-enforcement hours in his ward, he discovered that it would cost $600,000 in compensation payments in just the first three years. His chief of staff said, "Now these decisions aren't being made based on what's most efficient and what's best for small businesses. It's all about avoiding having to compensate the leaseholder."[39]

There are other public-policy effects, many probably unanticipated, of the parking-meter lease. The Chicago Transit Authority selected Ashland Avenue over Western Avenue for a proposed Bus Rapid Transit line in part because Ashland had fewer leased meters than Western.40 Illinois changed its law on disabled parking because of unanticipated compensation charges. It may well be good public policy that the disability law was modified—but in response to an unexpectedly onerous provision in a lease?

It is certainly possible to successfully involve the private sector in the installation, management, and operations of parking meters. However, because of their effects on public policy, parking meters and other similar items are not suitable for long-term leases to private entities.

3 CONCLUSION

The Indiana Toll Road and Chicago parking-meter leases provide i mportant lessons for governments considering major privatization transactions. The first is that, done correctly, privatization can be a big win for the public. The Indiana Toll Road lease is a case study in success. The second lesson is that the cost of getting it wrong can be high. Chicago's parking-meter lease is exhibit A in failure.

Picking the Right Asset to Privatize

Criteria	Better for Long-Term Privatization	Poorer for Long-Term Privatization
Tangibility of asset	Primarily tangible capital asset	Primarily intangible economic rights
Degree of overdetermined form	Higher	Lower
Connection to adjacent land	Weaker	Stronger
Connection to other policy considerations	Weaker	Stronger
Degree to which management must respond dynamically to change	Lower	Higher

Because of their long length, the stakes in these deals are higher than for outsourced services, such as printing or landscaping. Those deals typically have shorter durations and are regularly rebid. A 75-year contract can't be easily, or cheaply, renegotiated or terminated.

Getting long-term privatizations right starts with picking the right

asset (see chart). Toll roads have a track record of success. Assets that have similar characteristics, such as airports, are also more likely to be good candidates. Parking meters, or anything related to city streets, are poor candidates.

One final note: assets whose privatization would result in having to pay regular, recurring compensation to the lessee as part of the ordinary business of civic life—such as offering discounted parking to the disabled or closing streets for special events—are probably best kept under the day-to-day management of municipal government.

4 ENDNOTES

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WATER + ENERGY

WASTED:
HOW TO FIX AMERICA'S SEWERS

AARON M. RENN

In the nineteenth century, drainage problems and sanitation and health crises led many cities to develop sewer systems. In 1855, Chicago became the first U.S. city to have a comprehensive sewer system.1 Boston began building one in 1876.[2] Most of these early systems were built as so-called combined sewers—sanitary wastewater from buildings was combined with storm-water runoff into the same pipe system.

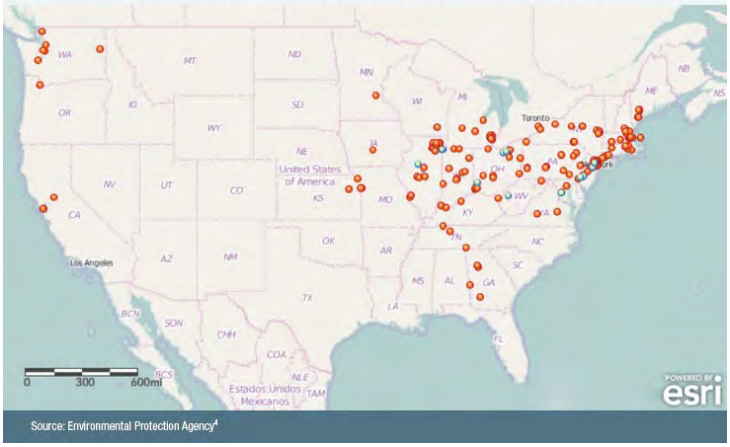
The alternative approach, a "separated" sewer system, which uses different pipes for storm-water runoff and sanitary wastewater, was also implemented in the nineteenth century, especially in Europe. But different rainfall patterns made combined sewers more attractive in America. Today, 772 U.S. cities have combined sewers, mostly in the older industrial regions of the Northeast and Midwest **(Figure 1)**.[3]

In the nineteenth century, sewage was not treated, so the choice of piping system did not affect treatment levels, as it would today. Recall, too, that this was the era of horse-drawn transportation: urban streets were full of horse manure and, often, dead animals;[5] industrial and stockyard runoff left waterways heavily polluted. For cities with occasional heavy rainfalls that made storm sewers a necessity, it did not make sense to build two sewer systems. For these cities, "dilution was the solution."

CONTINUED ON NEXT PAGE

FIGURE 1.

U.S. Combined-Sewer Systems Serving Populations of 50,000 or More



Source: Environmental Protection Agency[4]

1 COMBINED-SEWER OVERFLOWS AND THEIR REMEDIATION

Ultimately, sewage treatment was added for both combined sewers and the sanitary portion of separated systems. But for cities with combined sewers, there is an additional challenge. Normally, wastewater is treated—and thus is clean—before being discharged into local streams, rivers, and lakes. Heavy rainfall, however, can overwhelm the capacity of combined sewers and treatment systems. In these cases, the sewer systems will overflow, dumping untreated (if diluted) wastewater into local waterways at overflow points—"combined-sewer overflow" (CSO).

The Clean Water Act of 1972 targeted the cleanup of America's waterways from the legacy of the industrial age, including CSOs. In 1994, the Environmental Protection Agency (EPA) issued its CSO control policy, which requires cities to substantially eliminate CSOs in order to comply with the Clean Water Act. Though today the human-health impact of CSOs is limited, the federal mandate seeks to make local waterways clean enough for swimming and fishing.

The EPA has since undertaken enforcement actions and sued cities and independent sewer districts across the U.S. for noncompliance: under the "polluter pays" principle of environmental law, such entities are responsible for what were, at the time, legal and appropriate decisions. EPA-enforcement actions have frequently resulted in consent decrees specifying mandated investments to achieve compliance. But even without a consent decree, every city with combined sewers has had to take action to achieve compliance.

Remediation actions vary from place to place, depending on the specifics of the sewer system. Some cities are increasing their treatment capacity; others must upgrade the capacity of sewer lines to transport wastewater to the treatment facility. Some cities are constructing "deep tunnel" projects—large-diameter tunnels bored far underground to store excess wastewater that temporarily exceeds the system's treatment capacity; others are undertaking separation projects to separate sanitary and storm sewer pipes.

More recently, cities such as Philadelphia have turned to "green infrastructure" solutions, such as bioswales (gently sloping detention trenches with plants that filter and slowly discharge storm water into the ground), in an attempt to reduce storm-water runoff. Green infrastructure can be less expensive to install, can deliver benefits sooner, and can have more ancillary community benefits than traditional solutions. These various approaches to CSO remediation are typically implemented in combination, though the specific mix is unique to each city.

2 REMEDIATION COSTS

In a 2012 report to Congress, the EPA estimated a need for $48 billion in CSO-remediation capital projects.[6] Given the difficulty of estimating long-term costs, this may actually understate the total. The EPA's 31 current co sent decrees list $29 billion in projected costs for those 31 cities alone **(Figure 2)**.[7]

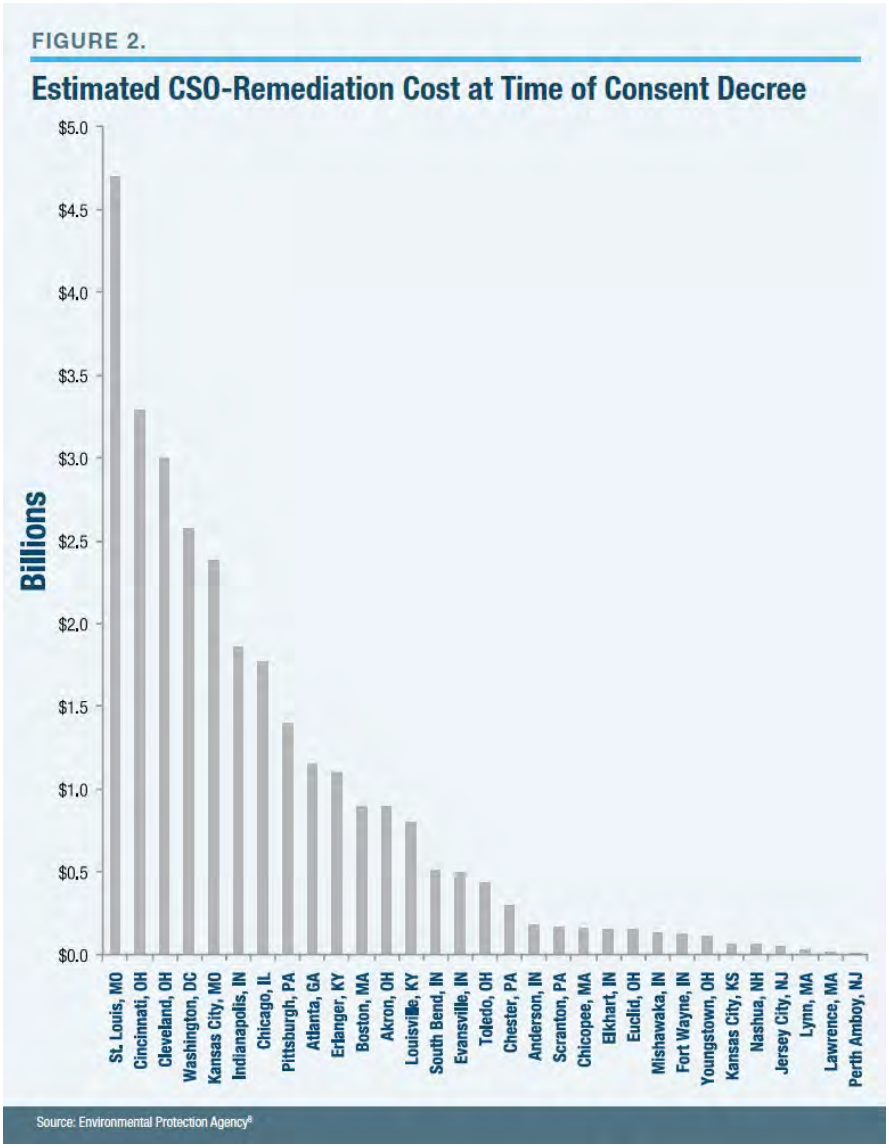
While CSO-remediation costs are highly variable from city to city, they can sometimes be astronomical. The following examples demonstrate the situations—and solutions—that five cities or independent sewer districts are pursuing.

Cleveland. Served by a regional utility, the Northeast Ohio Regional Sewer District (NEORSD), whose service territory includes 1.1 million people, Cleveland is a prime example. NEORSD's EPA consent decree anticipated $3 billion in capital investment. Savings identified during project development have reduced this amount by about $300 million, for a new cost of $2.7 billion. NEORSD's compliance plan, Project Clean Lake,[9] includes construction of seven major new tunnels, as wide as 24 feet in diameter.[10]

At the time the NEORSD consent decree was signed, the projected completion date was 2035, for an average of $135 million in annual outlays. Cleveland's 2015 general fund operating budget is $542 million:11 the sewer project's average annual cost thus is equivalent to 25 percent of the city's entire general fund operating budget. Or consider Cleveland's unfunded pension liability of $719 million[12]—making the sewer project nearly four times the size of Cleveland's unfunded pension liability. While the sewer district is independent of and larger than Cleveland itself, the cost of the city's CSO-reme-

FIGURE 2.

Estimated CSO-Remediation Cost at Time of Consent Decree



Source: Environmental Protection Agency[8]

diation initiative dwarfs every other major civic undertaking in the region.

St. Louis. The Metropolitan St. Louis Sewer District (MSD) is the fourth-largest wastewater agency in America, serving 1.3 million people over 525 square miles and covering most of St. Louis County and the independent city of St. Louis. MSD's project to remediate CSOs and other system issues is—in addition to the $2.7 billion in investments already made during 1992–2012—the $4.7 billion "Project Clear."13 MSD describes the work as "equivalent to constructing 11 Busch Stadiums, rebuilding I-64 nine times, or erecting seven new Mississippi River bridges."14 However, unlike those other regional capital projects, the sewer project is not easily visible to the public eye because so much of it is underground ("The $4.7 Billion Construction Project You Will Never See," was a headline in the *St. Louis Business Journal*).[15]

Over the 23-year implementation period, average annual expenditure will equal $203 million. In contrast, the 2015 general fund budget of St. Louis is $484 million;[16] the 2015 general fund budget of St. Louis County is $261 million.17 Average annual sewer project spending will thus equate to 27 percent of the combined $745 million city-county annual general fund budgets. (As with Cleveland, MSD is an independent agency.)

Philadelphia. Philadelphia has received significant press for being the first major city to attempt to meet CSO regulatory requirements using a primarily green infrastructure approach—the "Green City, Clean Waters" project.[18]

Combined sewers overflow because heavy rains overload pipes and treatment facilities. Green infrastructure attempts to address this problem by reducing the flow of storm water into the sewer system. Much of the storm water flowing into sewers is runoff from impermeable surfaces, such as roofs, asphalt streets, and parking lots. Green infrastructure seeks ways to allow this rainwater to be absorbed into soils naturally or to be otherwise captured on the surface without flowing into sewers. Philadelphia's green-infrastructure solutions include developing green streets with features such as bioswale-type landscaping and tree pits (similar in appearance to traditional tree lawns but designed to capture and manage storm water) and permeable pavements. Various green-drainage features in parking lots, green roofs, and elsewhere are also being pursued, as well as traditional, nongreen ("gray") infrastructure solutions.

Philadelphia's program is innovative but not cheap: $2.4 billion in capital over 25 years,19 nearly half as much as the city's $5.5 billion unfunded pension liability. However, using a green approach confers other advantages. First, unlike a deep tunnel, it can be deployed incrementally and deliver benefits sooner. Second, unlike underground storage tunnels, it can be used to provide landscaping and other urban greenery with ancillary value to the community. Most cities today are including at least some green elements in their CSO-remediation plan, but Philadelphia was the first large-scale plan to emphasize green infrastructure.

Buffalo. The Buffalo Sewer Authority (BSA) serves 450,000 people across 110 square miles in Buffalo and surrounding communities. Buffalo is fortunate: at an estimated $380 million over 19 years, its costs will be less than those of some other cities.20 About 30 percent of Buffalo's program is dedicated to green infrastructure. The BSA believes that the rate impact on customers, in terms of future increases, will be minimal and that much of the program can be financed

over time by borrowing more, as older bonds are paid off. Nevertheless, the majority of this money will come from ratepayers—Buffalo's unfunded pension liability is $141 million, or half the CSO-remediation bill. Though the BSA serves more than the city of Buffalo, this example again illustrates the scale of the CSO-remediation challenge.

Milwaukee. Milwaukee is a relatively unique case: it is in compliance with the Clean Water Act and so has zero CSO-remediation liability. In 1970, Chicago sued its neighbor to the north over sewer overflows into Lake Michigan, the source of drinking water to both communities.[21] In response, Milwaukee built a deep tunnel and other improvements to hold excess sewage to prevent overflows. Milwaukee's remediation program cost $3 billion; today, the city is able to treat 98.3 percent of all water during storms.[22] Indeed, the Chicago lawsuit turned out to be a partial blessing in disguise, spurring Milwaukee to get ahead of the CSO-compliance curve—and, as discussed below, to obtain federal grants to pay for more than half the project.

3 THE COMBINED-SEWER RUST-BELT CONNECTION

As Figure 1 shows, CSO-remediation costs—as with infrastructure repair challenges generally—are heavily associated with older industrial cities, which have seen large-scale job losses in manufacturing. Many Rust Belt cities have also lost population. Even in regions where the overall metropolitan population has grown, population loss in the core city (the older, central part of the region is where combined sewers are generally located) has been substantial—in some cases, half or more of the peak population. A high percentage of residents who remain are poor.

The federal government previously made construction grants available for wastewater projects, peaking at $7.3 billion in 1977.23 From 1970 to 1995, these grants totaled $60.9 billion,[24] helping some cities to get ahead of the curve on CSO remediation. Milwaukee, as noted, was one such city: the federal government paid 55 percent of the cost of its deep tunnel. While Milwaukee still had to pay a lot locally, the burden was significantly reduced, thanks to federal assistance. Starting in 1987, however, federal grants were substantially eliminated. Instead, such grants were used to capitalize State Revolving Fund loan programs (though some funds continued to be granted to local wastewater projects via earmarks). Henceforth, local wastewater utilities would primarily receive loans, not grants.

The net effect was to shift the cost burden of CSO remediation increasingly to local utilities, which would recover costs predominantly through sewer bills (though property taxes and non-ratepayer sources would be used, in some cases). As a result, the citizens and property owners of many of America's cities hit hardest by deindustrialization would also pay for the bulk of CSO-remediation costs.

Consider Cleveland, again. The city's residents and investors, as well as those in the surrounding suburbs that are part of its regional-sewer utility, are going to pay the majority of the costs of Cleveland's CSO-remediation project. The city's population, which peaked at 914,808 in 1950, had plunged to 389,521 by 2014—a decline of 57 percent. Cleveland's poverty rate is about 37 percent;[25] it has suffered large-scale deindustrialization; and it was one of the cities hit hardest by foreclosures during the subprime housing crisis.

Yet Cleveland is seeing nascent revitalization, especially in its urban core, of a type not seen in a long time. It added 4,000 residents to its downtown during the 2000s—a sea change in a city that has seen massive population loss. World-class institutions, such as the Cleveland Clinic, are growing. These positives would be brighter still if the city and its inner suburbs were not on the hook for a $2.7 billion sewer liability.

These huge sewer costs are, as noted, legally mandated by the federal government; localities have no choice but to spend the money. As Springfield, Ohio, mayor Warren Copeland complained: "This is the biggest, hugest unfunded mandate that I've ever seen in the time I've been in public life. Basically, the EPA at the federal level is prepared to tell us that we have to keep spending money and there's no help from the feds to deal with it. It's just a disaster from my point of view. There doesn't seem to be any way out of it."[26] This means major rate increases. For its part, Springfield has sufficiently satisfied the EPA that it is not under a consent decree; but it is still spending big, proposing to raise sewer rates by 7 percent (well above the rate of inflation) each of the next three years to help fund the program.[27]

The cumulative impact of these rate increases can be substantial. For example, in Providence, Rhode Island, the average sewer bill has gone from $130 annually in 1996 to $470 today, in part to pay for that city's remediation program. If its Phase 3 plans are approved, household bills will rise to $670 by 2020—a 43 percent increase in just five years—with more to come.[28]

The EPA does take affordability of sewer bills for residential customers into account when considering local remediation plans. Though it views affordability as a continuum, average residential sewer bills must, as a rule, exceed 2 percent of median household income to be classified as a "high" financial burden. The EPA should be given credit for including affordability in its enforcement actions. Yet its current measures of affordability, from both a resident and civic perspective, have significant limitations.[29]

One key limit of the EPA's approach is that the use of median income does not fully capture the impact of sewer bills on lower-income households. Jeff Rexhausen of the University of Cincinnati calculated the sewer-bill burden

for many large U.S. counties for those at the 20th percentile of household income. Select cities are shown in **Figure 3**.

In a number of cities, even current sewer rates represent a material portion of lower-income households' budgets. And not all these cities are in the Rust Belt, evidence that low-income affordability problems can affect any city. As Figure 3 shows, many of these significant sewer rate increases will be most keenly felt in low-income households: directly, as sewer bills for those who pay their own utilities; or as rent, for those who do not. The EPA's CSO-remediation mandates thus act as a highly regressive tax.

These household remediation bills may not seem much; but consider them in the context of surveys that find that a majority of Americans do not have enough money to pay an unexpected $500 expense.31 In Detroit, plans by the water and sewer department to start disconnecting customers for nonpayment provoked a political uproar among the city's low-income residents. For Americans living paycheck to paycheck, any increase in true essentials, like water and sewer service, makes a big difference.

This infrastructure squeeze on postindustrial cities is highlighted by the recent case of Flint, Michigan. Flint previously received drinking water from Detroit's water utility. By building its own pipeline to Lake Huron, the Flint area hoped to pay less than it would to buy water from Detroit. It would also decouple Flint from bankrupt Detroit, which hoped to use its water utility as a revenue generator.[32]

After Flint decided to build its own pipeline, Flint needed an interim water source and decided to utilize the Flint River. However, it failed to treat the river water properly, leading to contamination from water-pipe corrosion. Flint's lead water-pipe infrastructure could cost up to $1.5 billion to replace.[33] While Flint is a drinking-water, not a wastewater, matter, it has brought significant attention to the fact that shrinking postindustrial cities are unable to afford the staggering infrastructure costs that they face—the scale of which is of the same magnitude that some communities face for CSO remediation.

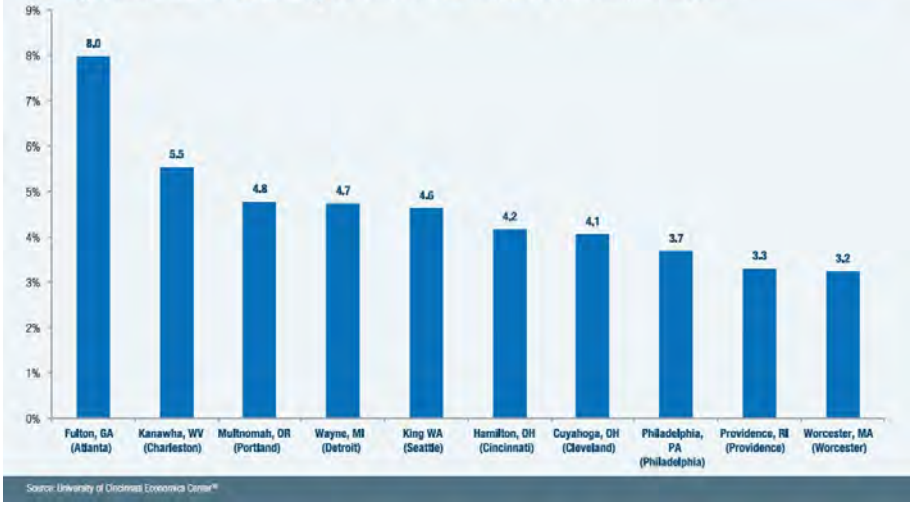
This challenge also illustrates the fact that these cities have far more infrastructure needs than CSO remediation alone, including items that more directly affect human health and well-being, such as replacing aging and leaky water pipes, repairing streets and sidewalks, and topping off unfunded pension funds. Each of these can run to over a billion dollars, depending on the city, and collectively pose an immense challenge to such cities. Because sewers are typically paid for

by utility ratepayers (not from the general fund) or are run by an independent sewer district, CSO remediation will not result in "crowd out" per se. But there is a limit to how much citizens and businesses can cumulatively pay for all these needs.

In addition to the direct burden on localities and their citizens, higher rates contribute to the overall cost climate that makes these cities less competitive for residents and businesses—not only compared with newer cities that have separated sewage systems but also, sometimes, with their own suburbs that have separated systems. Even where the combined-sewer service area is part of a larger regional sewer district, there are often newer suburban communities that are outside the "regional" district. While sewer bills are often not a major expense compared with some other items, increases from CSO-remediation initiatives constitute part of the overall stack of legacy costs.

FIGURE 3.

Average Sewer Bill as Percentage of the 20th Percentile of Household Income



Source: University of Cincinnati Economics Center

4 CONCLUSION

How should localities, as well as state and federal governments, respond to the CSO-remediation financing challenge, particularly in struggling postindustrial cities? Strategies could include embracing green-infrastructure solutions, optimizing local sewer rates and financing, revising federal affordability criteria, restoring direct federal grants for CSO compliance, and redirecting other funding streams to CSO remediation. Beyond policy, one needed change is simply to bring more public attention to the CSO-remediation challenge and the huge scale of the costs that it often imposes.

Embrace green infrastructure. Cities should aggressively evaluate and implement green-infrastructure solutions to CSOs; state and federal envi-

ronmental agencies should robustly support doing so, even if it means modifying previously agreed-upon remediation plans. Green infrastructure is preferred for two reasons. First, green—in this case—is the color of money: it is often cheaper; and let Philadelphia provide the template, with cost savings utilized as a guide to which green solutions make sense.

The second reason is that many forms of green infrastructure provide additional public benefit beyond simply eliminating CSOs. For example, bioswale-type storm-water detention along streets can be integrated as a form of landscaping and greenery. Indeed, many of these cities need to make investments in streets, anyway; doing so with a green street design can kill two birds with one stone. Conversely, the deep-tunnel concept of (extremely expensive) underground storage tunnels used only for storing excess wastewater—and then only a limited number of times per year in heavy rains—is an inherently dubious use of public funds.

One risk of green infrastructure is that long-term maintenance costs are not yet known. Additional analysis should be put into properly estimating long-run costs so that communities can make financially appropriate decisions on infrastructure in light of the total cost of ownership.

Revisit and optimize local sewer rate structures. Sewers are financed using different mechanisms in different cities. A utility that bills for sewage services, based on water consumption, is the principal model. (Utility charges can be flat rate, tiered, etc.) Some locations also obtain revenue from property taxes and other sources.

For example, Cleveland's system is financed through sewer bills, with a small residential base charge, plus a flat usage fee per thousand cubic feet of water consumed. Lower rates are available for those who can demonstrate financial need.[34] In Chicago, sewers are charged as a fixed percentage of the water bill. Some residential customers still have unmetered water and pay a fixed charge for service.[35] Others pay a volumetric rate.[36] Additionally, Chicago's Metropolitan Water Reclamation District, the agency that treats the city's wastewater, obtains financing from property taxes.[37]

A detailed recommendation for rate structures is beyond the scope of this paper. But localities—and states whose laws can determine local sewer financing—should examine their financing structures to optimize the way sewer costs are recovered to achieve the right balance: not burdening low-income households and not harming the business climate with excessive industrial-utility charges.

Revise federal affordability guidelines. The EPA should consider further revisions to its affordability guidelines for residents and communities to take a more nuanced account of lower-income residents and communities facing structural economic challenges, such as postindustrial cities.

Changes could include more specifically examining low-income households (not simply using the regional median income); adding criteria—such as the poverty rate, absolute unemployment rate, and totality of costs facing the community, including pensions and debt—to better identify distressed communities; and factoring in housing costs in higher-cost locations. Indeed, sound recommendations, based on detailed evaluations of the EPA's affordability criteria, have already been published.[38]

Renew federal construction grants for wastewater projects designed to comply with federal mandates. The federal government created the mandate for these localities to reduce their CSOs; it should put its money where its mandates are. This need not mean creating an open-ended program of renewed grants, but rather a limited program

designed to finance the transition to Clean Water Act compliance for these localities, of which CSO remediation is a part.

The $48 billion CSO remediation-cost estimate from the 2012 Clean Watersheds Needs Survey may be low. But if accurate—and assuming the previous 55 percent federal/45 percent local cost-sharing ratio—the program would require $26.4 billion over its lifetime to complete.

Provide additional state funding for CSO-remediation initiatives. Like distressed localities, many states have their own budget issues: state aid to localities was actually reduced in many cases during the Great Recession. Nevertheless, in many states, the state government is a financial partner with localities in infrastructure finance.

Some states are already evaluating proposals to increase their water and wastewater infrastructure funding assistance to localities. In New York, Governor Andrew Cuomo is proposing that the state provide $250 million in water and wastewater infrastructure assistance over the next two years—an increase of $100 million over the existing state support program.[39]

In Ohio, State Senator Joe Schiavoni has proposed a $1 billion program to provide state aid to localities for water and sewer infrastructure.40 He represents the Youngstown area, a classic postindustrial city working hard to renew itself but burdened with legacy liabilities, such as CSO-remediation costs, that it cannot afford to pay. Senator Schiavoni is the minority leader, so prospects for his legislation are uncertain. But the CSO issue is on the legislative agenda in Ohio.

Provide the flexibility to redirect existing funding streams to sewers. How should states and the federal government fundamentally respond to the challenge of postindustrial cities? In many cases, these cities are poor, shrinking, and with limited economic prospects. Some show nascent signs of revival but are far from a general turnaround.

A realistic assessment of their situation requires acknowledging that these types of locations are not presently in demand in the current economy. This does not mean giving up hope: cities like New York, once given up for dead, have revived.

But it does require understanding that government cannot conjure up economic growth in these places. Rather than attempt to restart growth, a better approach is to focus on

restructuring government and eliminating the legacy-liability stack. As long as there is a huge bill for things like unfunded pensions and CSO remediation, this will create a cost and risk disincentive to invest. Such cities' liability stacks pose a key challenge but one that can be addressed.

The focus of state and federal aid to struggling postindustrial cities should be liability elimination, including CSO remediation. One additional benefit of channeling aid to such an end is that it is virtually certain to succeed in accomplishing its objective. Many types of government-aid programs are speculative as to their outcomes; yet as a civil-engineering matter, CSO-remediation construction projects have a high likelihood of success.

Redirecting funds presently used for questionable transportation, economic development, or housing schemes to CSO remediation can reduce that liability with less recourse to the ratepayer. This approach would put cash in residents' pockets, especially the poor, and create a better cost profile for the city—if, and when, the market begins to favor it.

One way to do this is to provide additional flexibility in existing aid programs to allow localities to use the funding for CSO remediation. Today, the primary source of flexible funds that can be applied to sewers is the Community Development Block Grant (CDBG) program. Some places have used these funds for sewer projects. But most other funding streams are much more restricted.

Take highway spending. Federal and state highway aid is important to roadway maintenance. Yet in many communities, part of this aid is directed to highway expansion, a dubious use of funds in cities and regions that are not growing. There is, for instance, a plan to build a brand-new $300 million highway, the "Opportunity Corridor," inside Cleveland,[41] a shrinking city and region. But because federal highway money is available, Cleveland is chasing it. If the federal government allowed that money to be flexibly applied instead to the sewer project, it would chip away at Cleveland's massive liability.

Crumbling streets are, of course, also part of the liability stack of postindustrial cities. Yet if localities were allowed the flexibility to redirect some transportation funding to other capital needs, such as sewers, local leaders could decide which of their needs was highest priority. In addition to federal changes, granting such flexibility to localities would also require that state departments of transportation and regional metropolitan planning organizations, which allocate federal transportation aid, be on board.

In addition to new and expanded highways in shrinking regions, states have various business-subsidy programs that operate under the umbrella of economic development that are often dubious. New York State is investing $750 million—nearly double Buffalo's entire CSO-remediation liability—in a Buffalo-based solar-panel factory for the benefit of Solar City, a firm run by billionaire Elon Musk.42 States could include wastewater infrastructure as an eligible funding category under state economic-development assistance programs. Doing so might be far more beneficial to struggling postindustrial cities, which have few major employers seeking to locate there, than business-subsidy programs, from which they may never benefit in any material way.

Transportation funding and economic-development funding

are two potential types of funding sources where creative flexibility could allow local governments to better address pressing problems, like CSO remediation, that they are legally obliged to resolve. Again, one key benefit of directing intergovernmental aid to CSO remediation—rather than to economic-development or real-estate incentives—is that money spent on the former is almost certain to achieve its objectives. Water quality will improve, localities will be in compliance with the Clean Water Act, and local citizens and businesses will have more money in their pockets. This makes CSO remediation a low-risk investment.

Regardless of the package of policies implemented, some change to the CSO-remediation status quo is needed, especially for America's struggling postindustrial cities: it is unjust to make the disproportionately poor residents of these especially troubled places bear the burden of reversing rational decisions made in their communities in the nineteenth century

5 ENDNOTES

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EXPOSED:
HOW AMERICA'S ELECTRIC GRIDS ARE BECOMING GREENER, SMARTER—AND MORE VULNERABLE

MARK P. MILLS

Nearly everyone is aware of the deep interconnectedness of electricity in every facet of daily life. Less well understood is the enormous size and complexity of America's roughly $6 trillion electric utility system.[1] Unlike in many countries, the U.S. electric utility system is not a single grid. Rather, it is a complex web of eight regional "supergrids" coupled with thousands of local grids that deliver 55 percent of all the energy that America uses for non-transportation purposes.[2] Now, the U.S. electric utility system is on track to deliver an increasing share of the country's transportation energy, too.[3]

The August 2003 blackout that enveloped New York City and the Northeast—which put 50 million people in the dark for two days—inflicted $6 billion in damages.[4] That outage was caused by a confluence of human and machine factors, as are so many disasters in complex systems. Nature, thus far, is the most common source of grid outages. In 2005, Hurricane Katrina left nearly 3 million without power for several days.[5] ***CONTINUED ON NEXT PAGE***

In 2011, it was the lingering power blackouts that amplified the impacts from Hurricane Sandy—accounting for some 40 percent of the $50 billion in damages from that storm.[6]

The second most dramatic takeaway from widespread outages—after their economic and social costs—are the heroic efforts and speed with which electric utility crews effect repairs and restoration.[7] Utilities have long prepared for recovery: geographically widespread,

complex systems have unavoidable exposure to natural events and statistical failure modes. In the wake of the 2003 blackout, a Carnegie Mellon University study estimated that a blackout of that level is likely every 25 years.[8] In the meantime, smaller but still inconvenient outages—resulting from nature as well as other causes—are becoming more common.[9]

But America's electric sector faces two revolutionary changes. One is the emergence of so-called smart systems that promise vastly improved control and distribution of power across grid systems. The other is the pressure to add far more episodic (wind and solar) power sources that inherently require "smart systems" linked to the Internet.

Information and communications technologies (ICT) are now migrating from working mainly with information (i.e., the cyberworld) to an Internet of Things (IoT) that can also act directly in the physical world. This "cyberphysical" transformation holds the potential for greater efficiencies, convenience, reliability, safety, and predictability. For example, information systems are already very good at identifying and predicting road traffic and hazards, as well as informing drivers via maps and alerts. When that information is converted into a direct action as a cyberphysical system, one gets an "autonomous" (i.e., driverless) car.

Cyberphysical systems, however, bring a new class of risk; let's call it "cyber carjacking." In the summer of 2015, hackers remotely took over the steering and braking of a Jeep Cherokee **(Figure 1)**.[10] That wake-up episode led to a 1.4 million vehicle recall by Chrysler.[11]

In pursuit of environmental aims, U.S. policymakers and regulators are rushing to improve energy efficiency and integrate episodic power sources—i.e., wind and solar—onto electric grids. This has involved pushing utilities and federal and state governments to spend tens of billions of dollars on smart-grid technologies. For everything from cars to aircraft to health care, regulators have emphasized a safety-first approach to technology. That has not been the case thus far with regard to ensuring the cybersecurity of America's evolving electric grid.

This head-in-the-sand attitude may be slowly changing. The December 2015 hacker-caused blackout of Ukraine's electric grid helped raise red flags, as did the discovery that, in 2016, Iranian hackers used a process called "Google dorking" to hack into a small New York dam's control system.[15] The Ukraine hack, ostensibly by Russia, used malware called "BlackEnergy" combined with other cyber and espionage tactics. Arguably the first wake-up call regarding the capabilities of cyberphysical attacks came in 2010, when the world learned of a clandestine project (ostensibly U.S.-Israeli) using the Stuxnet computer virus to severely damage the electrical infrastructure of Iran's nuclear facilities.[16]

Last year, Lloyds Bank published a comprehensive study of worst-case scenarios "to bring awareness to the potential physical damage caused by cyberattacks against Operational Technology" and, in particular, "the U.S. power grid." Lloyds noted that, while the scenarios considered were still "improbable," they were nonetheless "technologically possible."[17] A worst-case multipronged, multiregional cyberattack causing widespread outages could inflict $243 billion–$1 trillion in total damage on the U.S. economy, Lloyds found.

Current electricity policies, as will be discussed in greater detail below, run the risk of creating the conditions for a perfect cyberstorm by prematurely pushing the Internet of Things onto

FIGURE 1. ANATOMY OF A CYBERPHYSICAL HACK

In 2015, researchers Charlie Miller and Chris Valasek took control of a Jeep from ten miles away.[12] The engineers looked for a vulnerability in Sprint's cellular network that connected to the vehicle's music and radio system, and then hacked the password. Next, exploiting the fact that a Jeep's entertainment system is physically connected to the power system, they remotely uploaded new code onto the car's microcomputers (all on the same power network) that controlled steering and antilock brakes. Chrysler and the cellular carrier have since corrected those particular vulnerabilities; but cyberphysical systems remain complex, diverse, and rapidly evolving.

The challenge for electric grids across America comes from the push for greener, smarter grids, wherein all such technologies demand real-time controls and Internet connections. Smart appliances, solar arrays, battery-storage, and demand-management technologies require the kind of computer-based controls—the equivalent to automotive antilock brakes and power steering—to manage the episodic, varied nature of power demand and supply on grids required to meet society's 24x7 needs. Engineers and cyber experts have understood for years the nature of such exposure.[13] But now, the proliferation of real-time networked controls on grids will vastly increase the variety and scale of the cyberattack surface.

For aircraft and cars, safety and security take priority over the efficiency and convenience gains from using automated and networked controls. Not so for U.S. power grids, where cyberphysical security has taken a backseat to policymakers' push for green-energy priorities. Even when cybersecurity is on the political front burner, the utility sector is frequently omitted. The president's new Commission on Enhancing National Cybersecurity, for instance, includes no appointees from the infrastructure and electric sectors.[14]

grids to accommodate environmental goals—and doing so at a time of growing cyber capabilities of bad actors, and exactly when society is becoming increasingly dependent on electricity.

1 THE U.S. IS INCREASINGLY DEPENDENT ON ELECTRICITY

Individual data centers—the central power plants of the Internet—consume as much power as steel mills.[18] Yet only several decades ago, data centers did not exist as a category for tracking electricity use.[19] Even more than factories,

data centers must run 24/7. And while data centers—enormous information "factories"—today consume more U.S. electricity than America's steel industry, they account for only a fraction of the information ecosystem's total power needs.[20]

Overall, the U.S. economy is more dependent on the information-centric and electric-dependent sector than the transportation-centric, oil-dependent sector that dominated the twentieth century: activities

associated with transporting goods and people account for about $500 billion of U.S. GDP; the comparable figure for creating and transporting information is $1.2 trillion **(Figure 2)**.[21]

This dependence on electricity-using data networks is growing. Cisco Systems, a maker of computer-networking devices, forecasts U.S. data-center traffic to nearly triple in five years, with much of that growth coming from the explosion of video content.[23] Cisco also projects a tenfold rise in data traffic from the Internet

of Things, including from machines in homes, cars, stores, factories, hospitals, and, especially, utilities.[24] By one estimate, global IoT data traffic could require as many as 4,000 new data centers, creating an aggregate power demand fourfold that of California's grid.[25] Many of those data centers will be in America. While information hardware will continue to become more efficient, overall ICT power demands will continue to grow.[26]

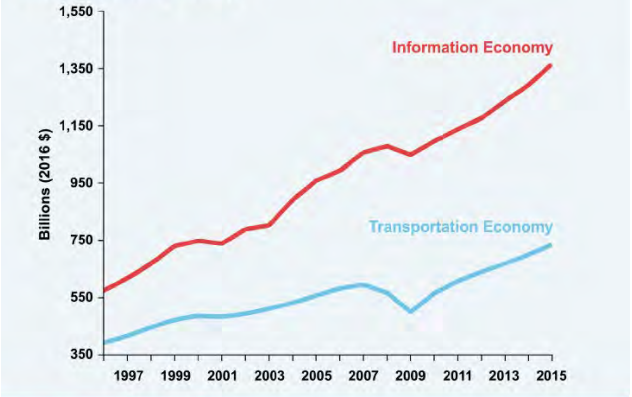
Then there are other electricity-consuming tech trends, including 3-D printing, data-centric health care, and electric vehicles (EVs). The U.S. Energy Information Administration's (EIA) forecast for EVs on U.S. roads by 2030 represents adding the electric-load equivalent of 5 million homes.[27] Other, more ambitious, EV forecasts add demand equivalent to 40 million homes.[28]

Rising urbanization—in the U.S. and globally—deepens electric dependency, too. Cities, inherently highly electrified **(Figure 3)**, will see accelerated dependence with the "smart city" movement, wherein everything from traffic to building operations to public services and safety are Internet-connected.

While energy efficiency is projected to improve, the EIA forecasts that America will use about 10 percent more electricity two decades from now.[30] Over the same period, the EIA forecasts essentially no growth in U.S. transportation oil demand. These two trends mean that the U.S. economy will become yet more dependent on fuel delivered by the kilowatt-hour in wires, not by the gallon in pipes. The big challenge remains: to ensure that this electricity reaches our homes, hospitals, and businesses whenever we need it.

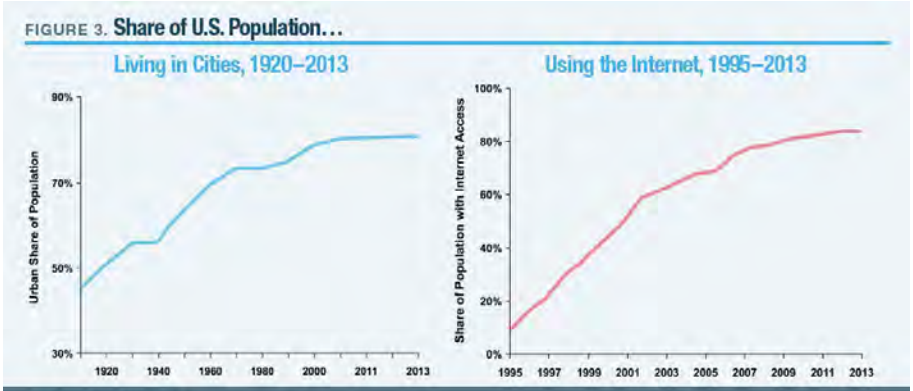
FIGURE 2.

U.S. GDP Associated with America's Transportation and Information Sectors



Data Source: U.S. Bureau of Economic Analysis[22]

FIGURE 3. **Share of U.S. Population…**



Source: Kleiner Perkins Caufield & Byers[29]

2 THE ELECTRICITY BALANCING ACT

Unlike many other countries, the U.S. does not have a national electric grid. Instead, it has a complex array of grids, a "system of systems." There are two classes of U.S. grids, as well as many separate individual grids within them.

One class consists of North America's eight longhaul grids, Regional Transmission Operators,[31] which move "bulk power" from remote power plants to cities, each of which has regional subdivisions **(Figure 4)**. The longhaul grids are overseen by the North American Electric Reliability Corporation (NERC) and are regulated by the Federal Energy Regulatory Commission (FERC).

The second class of U.S. grids includes thousands of independent local distribution grids, from small towns to the biggest metropolises. These grids are owned, or used by, more than 3,000 utilities. About 200 of the utilities are investor- owned, about 900 are rural cooperatives, and about 2,000 are publicly owned municipal entities.

With every other commodity's supply chain—including oil, natural gas, minerals, and agricultural products—there are typically one to several months' worth of demand in storage to ensure reliable delivery to markets. Given the physics of storing power, however, 99 percent of electricity has to be generated the same instant that it is consumed.

Today's central engineering challenge is to deliver power continuously—and nearly instantaneously—over vast geographic areas in the face of inevitable plant failures, weather, and fluctuating demand.

The invisible balancing act needed to keep huge power flows stable can be loosely analogized to trying to run with a shallow pan full of water without spillage. If grids are not balanced continuously, critical voltage or frequency control can be lost, leading to outages, damaged customer and utility equipment, and, in some cases, the destruction of grid hardware. To counter such risks, grids have long been fitted with sensors, protective relays, backup systems, safeguards, and manual overrides, as well as with various supervisory control and data acquisition systems (a kind of precursor industrial "internet" used in nearly all industries and infrastructures).

FIGURE 4.

America's Eight Long-Haul Transmission Grids

Ultimately, technology will permit America's electric grids to operate in a fashion more akin to the Internet: one day, the grid will be nodal, interactive, and highly controllable, with smart power-flow routing, microgrids, solar energy, and batteries all playing a role.

Next-generation high-power semiconductor technologies are emerging to make grid-level dynamic switching and control possible; but such technologies will take time to deploy and to ensure that they are cybersecure. Still, when such power control becomes widespread, the primary benefits will extend beyond enabling more EVs and solar on grids. Above all, the benefits will involve enabling better security and reliability.

To date, however, spending to make the grid smarter has been dominated by making it easier for utilities to bill customers, or promote conservation and green energy.[32] Adding communications features to meters is comparable to installing a speedometer or gas gauge—it is not a game-changer. The game-changer involves controlling grid-power flows and doing so securely.

3 BLACKOUTS: PAST, PRESENT, AND FUTURE

Electric power outages are becoming more frequent **(Figure 5** and **Figure 6)**. Since 1990, the average incidence of outages on U.S. grids has increased by about 8 percent per year,[33] while the annual outage duration has risen by about 14 percent per year.[34]

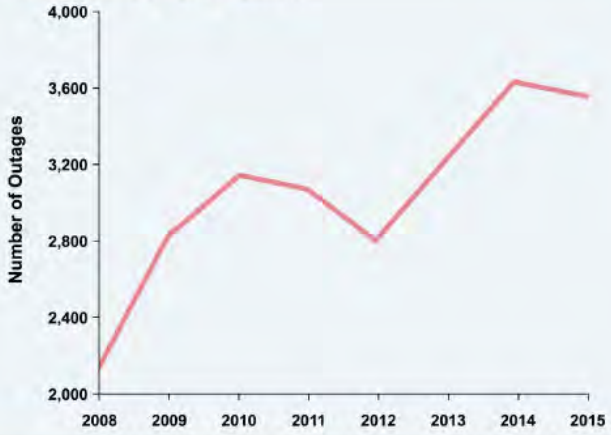
The social disruption—not to mention the costs—wrought by blackouts is substantial. **(Figure 7)**. Consider New York City, which, on August 31, 1959, was struck by the world's first major electric-power outage. Triggered by a heat wave and surging air-conditioning use, the outage wiped out power across 500 blocks of Manhattan for 13 hours.[35] On November 9, 1965, 30 million people in the Northeast, including millions of New Yorkers, were plunged into darkness for 18 hours. That blackout inspired books and movies, mostly about heroic behavior and rediscovered neighborliness, and led to the creation of NERC, which established standards and oversight to improve long-haul grid reliability.

New York City's most infamous blackout struck on July 13, 1977.[37] The outage lasted 25 hours and sparked mass looting and arson—1,600 stores were ransacked, and more than 1,000 fires were lit[38]—prompting more than 4,000 arrests and headlines such as "Night of Terror."[39] The total damage was estimated at $300 million. New York City has since suffered three more blackouts, all a product of nature and machine/human failure.

Today, all major cities use far more electricity than New York City consumed on the eve of its disastrous 1977 blackout. Meanwhile, a new phe-

FIGURE 5.

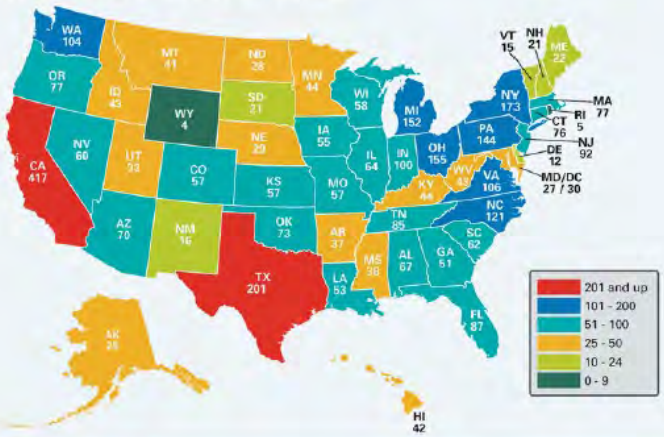
U.S. Electric Power Outages



Data Source: Eaton Blackout Tracker

FIGURE 6.

Power Outages in 2015 by State



Data Source: Eaton Blackout Tracker

nomenon has emerged for utilities, with important implications for reliability: peak demand for power has become far more volatile.

For more than a decade, there has been a widening gap between the growth rate in energy used to make electricity and the growth rate in peak demand **(Figure 8)**.[40] As a result, an increasing share of standby generating capacity is required to meet frequent, episodic peaks. This also means that for many utilities, as much as 70 percent of total costs are associated with capital equipment (power plants, wires, hardware) to ensure peak-delivery capacity. These costs and hardware are essentially independent of how much energy is consumed. Put another way: reliability is determined more by the amount of capital spent on hardware to ensure that energy is available when needed, rather than on the money spent producing the energy itself.

This trend is visible across America, including New York City.[41] Official forecasts expect little growth in New York City's average utility energy consumption; but peak demand is expected to rise sharply, from 160 percent above average demand in 2003 to 220 percent above average demand in the next decade.[42]

The challenge of dealing with increasing disparity between peak and average demand will be radically exacerbated with the addition of more episodic, or peak, supply from solar and wind. This new challenge is particularly clear when viewed on an hourly basis in California, where the rapid growth in green energy will cause the daily peak-to-valley ratio to rise from 115 percent in 2012 (i.e., meeting peak demand required 115 percent of base generation) to about 145 percent in 2020 **(Figure 9)**. As the California ISO, the state's transmission authority, notes, this will "require flexible resource capabilities to ensure green grid reliability."[43]

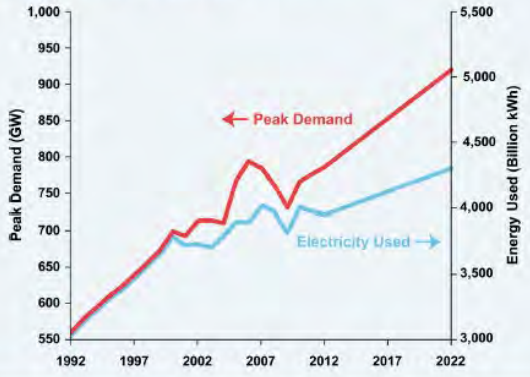
America's "information utilities" (i.e.,

FIGURE 7.
AMERICA'S TEN WORST BLACKOUTS[36]

1. **August 14, 2003:** 50 million people lose power across the Northeast
2. **November 9, 1965:** 30 million lose power across the Northeast and in Ontario, Canada
3. **July 13, 1977:** 9 million lose power in New York City
4. **October 22, 2012:** 8 million lose power across the Northeast
5. **August 10, 1996:** 7 million lose power across the West
6. **December 22, 1982:** 5 million lose power across the West
7. **June 29, 2012:** 4 million lose power across the Midwest and the Northeast
8. **October 29, 2011:** 3 million lose power across the Northeast
9. **September 8, 2011:** 3 million lose power in California and Arizona
10. **July 2, 1996:** 2 million lose power across the western U.S., Canada, and Mexico

FIGURE 8.

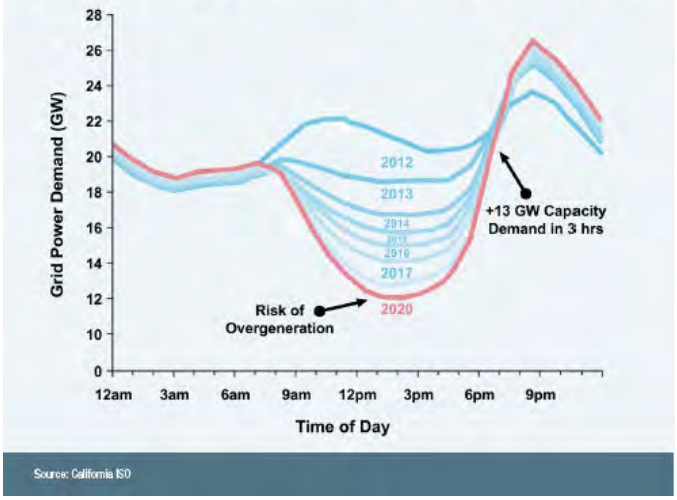
U.S. Electricity Energy Consumption v. Peak Power Demand



Data Source: Electric Power Research Institute and EIA

FIGURE 9.

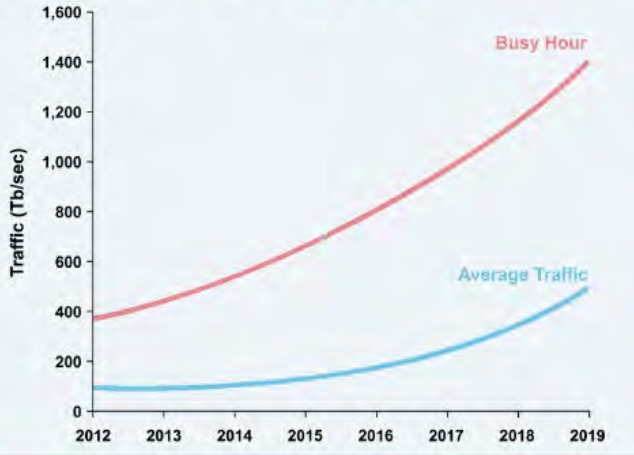
Daily Variation in Electricity Demand, California Grid



Source: California ISO

FIGURE 10.

Peak v. Average Global Data Traffic



Data Source: Cisco[45]

data centers) are also seeing surging peak demand. According to Cisco, the gap between peak data traffic and average data traffic (visible in its tracking of global data use) will widen hugely in the coming decade, from 200 percent today to nearly 700 percent within a few years **(Figure 10)**.[44]

There are two main tools to manage peak demand of anything: build extra capacity, or incentivize customers to consume less during peak times. Information utilities use the former, furiously expanding infrastructure to meet demand. Electric utilities—prodded by regulators—prefer the latter, harnessing technology and price incentives to moderate peak demand.

Peak electricity-management techniques require substantially increasing communications and controls. In other words, they require a far greater expansion of the Internet of Things onto local grids.46 The majority of products forecast for the growing residential IoT sector are associated with controlling electricity by integrating information controls—i.e., adding "smart"—into meters, thermostats, air conditioners, heaters, lights, PV systems, batteries, and EV chargers.[47]

Without a more widely networked, IoT-centric electric grid, meeting peak demands, ensuring reliability, and, as discussed later, fuller deployment of solar and wind sources will be impossible. The current rush to push the Internet of Things onto the electric grid will dramatically raise the risks of cyberattacks. Asked for his view of the Internet of Things, Jerry Irvine, a cybersecurity expert, responded: "Scary as hell."[48]

4 GRID 2.0: A CYBERPHYSICAL TARGET FOR HACKERS

There are two main types of cyber targets: cyber information targets and cyberphysical targets. The vast majority of cyberattacks fall into the former, which includes theft of financial and other personal information, theft of business secrets, and harassment, such as "distributed denial of service," or DDoS, attacks to overwhelm and shut down websites.

But cyberphysical targets are becoming more vulnerable and more attractive to bad actors.[49] In 2000, in the first known example of a malicious breach into an industrial control system, an angry ex-employee hacked an Australian water-services plant and released tons of sewage into local parks and rivers.[50] In 2003, after a consultant inadvertently bypassed a firewall, Ohio's Davis-Besse nuclear plant's control room was infected by the Slammer cyberworm, which then blocked the plant's automated sensors.[51]

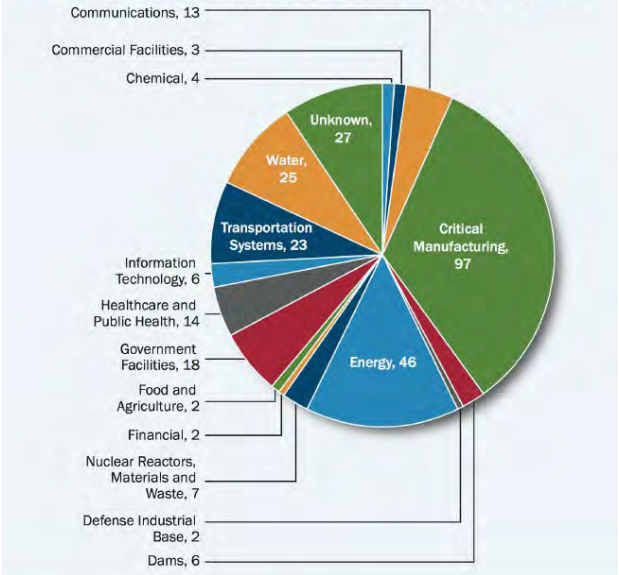
Still more recently, in 2012, hackers wiped out the hard drives on 35,000 Saudi Aramco computers, temporarily compromising all back-office operations of the state-backed oil giant. Shortly before the 2014 Winter Olympics, a hacker gained access to the heating, cooling, and emergency-response systems of Russia's Sochi arena.[52] In 2015, German engineers discovered that hackers had breached the operating system of a steel mill, causing "massive physical damage."[53] In America, cyberterrorists are broadening their reach beyond their traditional financial and personal-information targets to include the power systems and the machines inside hospitals. Their goal: "Bring these hospitals to a standstill."[54]

Measuring the precise number of attacks on cyberphysical systems is not easy, since there are many standards and definitions. But the reported trends are clear: hackers are increasingly targeting infrastructure systems.

According to computer firm CDW, in 2015, the number of cybersecurity attacks at U.S. utilities exceeded 7,000. America's oil and gas sector experienced more than 5,000

FIGURE 11.

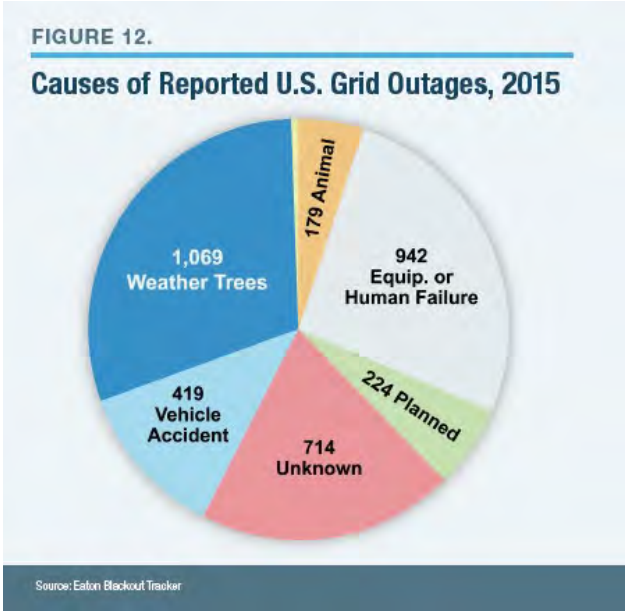
U.S. Targets of Cyberphysical Attacks by Industry, 2015



Source: National Cybersecurity and Communications Integration Center[59]

FIGURE 12.

Causes of Reported U.S. Grid Outages, 2015



Source: Eaton Blackout Tracker

attacks.[55] According to Tripwire, an IT security firm, 75 percent of utilities report that at least one cyberattack defeated their firewalls and antivirus programs in 2015, and 80 percent worry that a future attack could cause physical damage.[56] PwC, an auditor, reports that cyberattacks on the U.S. utility sector perpetrated by organized crime doubled in 2015.[57] According to the federal National Cybersecurity and Communications Integration Center, America's manufacturing and energy sectors are the top two targets for attacks on cyberphysical systems **(Figure 11)**.[58]

In another study, Cisco found that over 70 percent of utility IT security professionals discovered a security breach in 2015, compared with 55 percent in other industries.60 U.S. utilities were among the top five most exposed American industries to malware, says Cisco.[61] Some security experts even warn that the "next Cold War has already begun—in cyberspace."[62]

To win this new cyber war, America must keep electricity and other critical infrastructure off the front lines. Alas, simply detecting attacks can be difficult. The SANS Institute, a cybersecurity research outfit, says that, when it comes to the Internet of Things, "it's almost impossible to tell how often" industrial controls are breached or "how it's done."[63] According to Tripwire, only 43 percent of energy executives believe that their firms have detected all cyberattacks committed against them.[64] AT&T says that, in 2015, there was a 458 percent increase in the frequency with which hackers probed IoT connections for vulnerabilities.[65]

Where are the vulnerabilities? Utility smart meters, one of the most prominent ways that the Internet can be connected to the electric grid, are one. Since 2010, the number of smart meters in the U.S. has soared, from 10 million to more than 50 million.[66] But in the years to come, smart meters will represent only the tip of the iceberg of vulnerabilities in an expanding attack surface of IoT-enabled devices connected to grids.

The proliferation of Internet-connected things with direct access (or back doors) to electric grids is not the only threat to their security and reliability; so, too, is the push to accelerate a fully cyber-connected electric grid. Meanwhile, the SANS Institute reports that only 29 percent of U.S. companies are beginning to implement a cyberphysical strategy, 33 percent are still developing a strategy, and 18 percent have no plans to develop a strategy.[67]

There are yet no documented cases of terrorist attacks triggering U.S. power outages. Still, it is possible that cyberattacks may be to blame for some outages that have been categorized as "faulty equipment" or "unknown" causes **(Figure 12)**. It is a near-certainty, however, that "cyberattack" will soon become a new category for power-outage tracking.

5 GREEN ENERGY V. CYBERSECURITY

State and federal mandates (including the federal Clean Power Plan) seek to move U.S. electricity generation away from fossil fuels and toward renewable power sources. Total federal and state support for green-energy tech over the past decade exceeded $175 billion.[68] By comparison, over the past half-dozen years, the DOE invested a total of only about $150 million on cybersecurity research projects.[69] The risks inherent in this asymmetry are not only associated with a lack of emphasis on cybersecurity; they also involve the structural changes being brought to U.S. grids that increase cyberphysical risks because of the nature of wind and solar generation.

State policies requiring green mandates have resulted in wind and solar constituting about 75 percent of all

new electricity capacity added to U.S. grids in the past decade **(Figure 13)**. This trend creates new pressures on utilities to integrate the vagaries of wind and solar power into their grids, which require power to be available on demand.

Yet integrating episodic renewable energy with the continuous need for power—especially with today's surging peak needs—requires an entirely new level of control, integration, and networking. Adding that kind of real-time control with the Internet of Things dramatically increases the opportunities available for cyber-attacks—i.e., it greatly expands the "attack surface."

The core issue is the requirement for high-availability energy sources to operate a reliable grid. Today, about 90 percent of America's power comes from readily available sources: 33 percent each from coal and natural gas, 20 percent from nuclear, and 5 percent from hydro dams.70 Meanwhile, wind and solar power have low average availability. Worse, wind and solar have zero availability for many hours each day. Neither wind nor solar output can increase to accommodate surges in peak demand, either.

Solar and wind power can operate successfully thus far because of America's surplus of other, high-availability sources. Texas and Iowa, the largest and second-largest wind-generating states, get 70 percent of their electricity from natural gas, coal, and uranium.[71]

Proposals to incorporate vastly more wind and solar on U.S. grids offer essentially two technology solutions to deal with the availability problem: a more networked grid and a grid with far more storage. The former would represent a radical acceleration of the Internet of Things; the latter requires the pursuit of new, radically better, classes of physical chemistry.

Storing large quantities of electricity **(Figure 14)** has frustrated engineers since the dawn of the electric age. Bill Gates, now an investor in a number of new battery companies, has summarized the challenge: "The biggest problem for the two lead candidates [wind and solar] is that storage looks to be so difficult.... We're more than a factor of 10 away from the economics to get [grid-scale storage]."[72]

Utility-scale battery storage has grown nearly 20-fold in only a few years. But that storage still constitutes less than 0.01 percent of overall U.S. grid supply.75 Even if California, which has America's most aggressive storage mandate, achieved its storage goal by 2020, the storage would provide barely 2 percent of California's peak-power needs.[76]

Regardless of the hopes for breakthrough discoveries in battery technology, there is no realistic prospect for storing electricity as a viable solution to the episodic supply of wind and solar energy.[77] For this reason, green-power advocates view the use of networks (wires) and (smart) network controls as the means to align episodic supply across geographic regions with market demand—combined, as a last resort, with greatly expanded backup from natural-gas generation. But all these solutions greatly increase cyberphysical- and physical-attack surfaces.

More transmission lines (long-haul and local) increase exposures to conventional causes of outages. Increasing the share of U.S. electricity supply coming from natural gas means that it is now important to consider the physical and cyber vulnerability of the gas infrastructure as an additional vector for electric outages. As noted, far greater use of IoT-type network controls also creates a "magnet" for hackers. Finally, it's not just smart meters and other grid IoT devices that are vulnerable. Cyber backdoor exposure is inherent in the control systems embedded in many solar panels and wind turbines themselves.[78]

FIGURE 13.

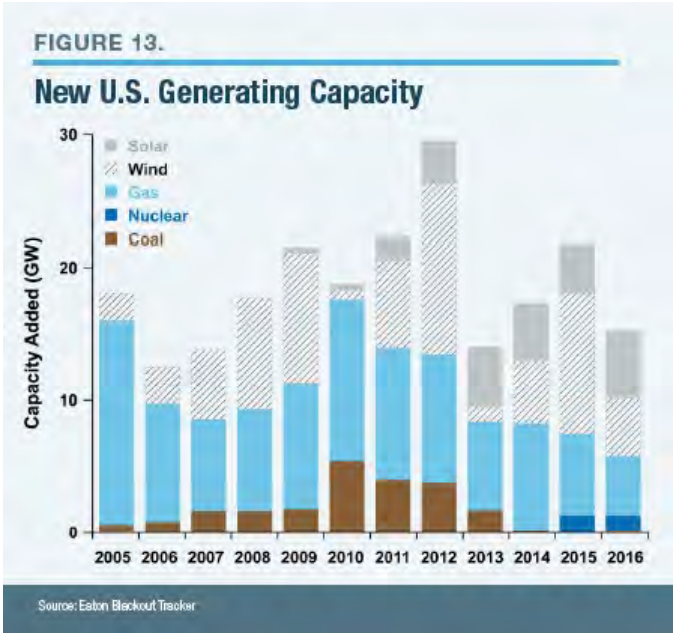


FIGURE 14. BATTERY-STORAGE REALITIES

The sheer scale of batteries needed for grid-scale storage (ignoring costs) makes clear the engineering challenge to create U.S. utility systems dominated by episodic power. The total amount of electricity stored at any given moment in all the batteries in America for all purposes—laptops, cars, phones, flashlights, etc.—is countable in just minutes' worth of daily U.S. electrical demand.[73]

The enormous $5 billion Tesla battery "gigafactory" under construction in Nevada will produce a quantity of batteries each year that can store 30 billion watt-hours of electricity.74 Yet that huge quantity of battery supply is a drop in the bucket compared with America's daily consumption of 10,000 billion watt-hours. It would take 100 years for the Tesla factory to manufacture a quantity of batteries capable of storing a half-day's worth of U.S. electric demand.

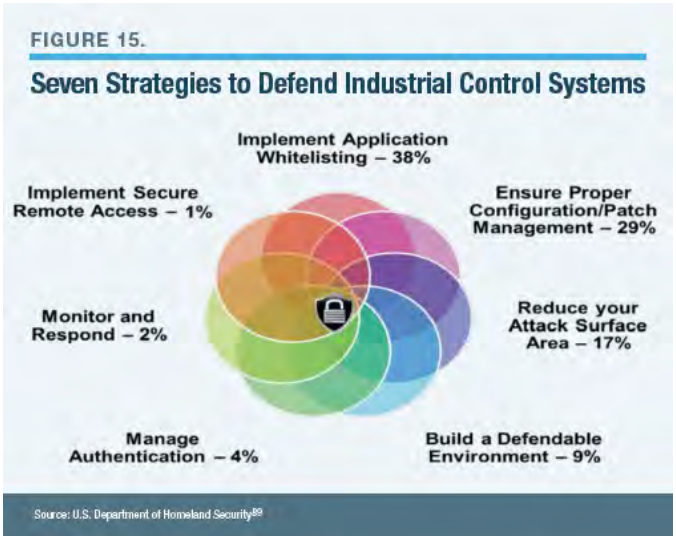
6 THE STATE OF U.S. GRID CYBERSECURITY

The prospect of a hacker turning off all of America's lights in a single attack is wildly implausible: to simultaneously bring down all of the country's distributed patchwork of grids (see Figure 4) would be borderline impossible and would, in any case, require nation-state-class capabilities. Even the major 2015 cyberattack on Ukraine's grid affected only about 250,000 residents.[79]

After the Ukraine attack, Gerry Cauley, CEO of the North American Electric Reliability Corporation, testified before Congress,80 noting, correctly, that U.S. long-haul grids have important technical and operational advantages[81] over Ukraine's (far smaller) grid and that Ukraine was brought back online in only several hours. Though NERC requirements for long-haul grid cybersecurity will escalate in July 2016 with expanded requirements for critical infrastructure protection (CIP) standards,82 Cauley nonetheless cautioned that U.S. utilities "will need unprecedented levels of financial resources in order to restore their facilities and eventually resume normal operations" after a successful cyberattack.[83]

It is on local U.S. distribution grids—which will not be covered by NERC CIP standards—where the rush is greatest to add Internet-connected devices and green-energy sources. Ironically, while concern over cybersecurity is slowing the adoption of the Internet of Things in many industries, this is not the case for U.S. utilities, which are particularly susceptible to political pressure.[84]

State and federal policies continue to promote or require far greater use of both green energy and Internet-connected smart-grid features. Even though the Energy Policy Modernization Act,[85] passed by the Senate in April 2016 with a bipartisan majority, includes an amendment to the Federal Power Act to authorize the U.S. secretary of energy to "take such actions as the secretary determines will best avert or mitigate [cyber threats],"[86] the bill has several alarming features. It expands and concentrates U.S. cybersecurity authority at the federal level, a development unlikely to boost the speed or flexibility needed to counter such threats. The bill does not cover local U.S. distribution grids, which are far more cyber-vulnerable than long-haul grids. And it expands America's cyberphysical attack surface by promoting the smart- and green-grid transformation already under way.



Consider another example of muddled federal priorities. In December 2015, the Department of Homeland Security issued cybersecurity guidelines[87] **(Figure 15)** for industrial control systems **(Figure 16)**. According to the DHS, following the guidelines would have "prevented 98% of the [cyber] incidents reported in FY2015."[88] Among others, the DHS guidelines recommend reducing industrial control systems' attack surface as well as allowing "real-time external connectivity only when absolutely necessary"—a policy at odds with the federal push for smart-greening America's grid.

U.S. policy schizophrenia on security and green goals is persistent and pervasive. A 2013 White House report[93] that urged greater grid reliability (albeit with a focus on "weather-related outages") also promoted the very technologies that will undermine reliability by expanding grids' cyberattack surface.[94] State policies are no more coherent. New York governor Andrew Cuomo's new "Reforming the Energy Vision"[95] initiative pays lip service to grid security—"[The] availability of reliable, resilient, and affordable electric service is critical to the welfare of citizenry and is essential to New York's economy"—while promoting grid programs that make cyberphysical attacks easier to carry out.

The U.S. Government Accountability Office is not impressed with the state of cybersecurity of America's utility infrastructure, either. In a 2015 report, the GAO warned that:

1. FERC has not taken steps to monitor [the electricity industry's] compliance with voluntary [cybersecurity] standards.
2. Entities in the electricity industry (e.g., utilities) often focused on complying with regulations rather than taking a holistic and effective approach to cybersecurity.
3. Smart grid devices (e.g., meters) did not always have key security features such as the ability to record activity on systems or networks, which is important for detecting and analyzing attacks.
4. The electricity industry lacked sufficient metrics for determining the extent to which investments in cybersecurity improved the security of smart grid systems.[96]

When combined with the rising tech-savviness of groups hostile to America, as well as rising urbanization, federal and state policymakers' prioritization of environmental goals over grid security is making America more exposed to cyberattacks.[97]

FIGURE 16. INDUSTRIAL CONTROL SYSTEMS AND THE INTERNET OF THINGS

The digital age of Industrial Control Systems (ICSs) began in 1968 with the invention of the programmable logic controller (PLC). (The Stuxnet virus attack in 2010, against Iran's uranium centrifuges, targeted PLCs, one of the few documented examples of a digital weapon destroying a physical asset.)90 In 1986, the first PLCs were tied to personal computers; in 1992, PLCs were linked to a local Ethernet using Internet-communications protocols, and in 2003, the first PLCs were embedded in Web servers.[91]

PLCs, sensors, relays, meters, and the like are all connected, monitored, and operated by a supervisory control and data acquisition (SCADA) system, a kind of "industrial Internet" used across industries, especially in the electric sector. While SCADA dates back over a half-century—largely because of the need to operate electrical systems over broad geographic areas—integration with the Internet (whether in factories or on utility grids) is the newest phenomenon in the progression of ICSs.

Today, millions of utility remote terminal units, sensors, meters, actuators, controls, and SCADA systems exist across America's hundreds of local and connected grids, as well as across its long-haul grids. Millions more exist in factories and office buildings—and soon, in homes. And, until recently, ICSs largely existed in operational silos that were far less vulnerable to cyberattack.[92]

7 CONCLUSION

Hackers typically fall into two groups: private individuals or organizations with varying skill levels who hack for financial, nuisance, or harassment motives; and nation-state or nation-sponsored entities with high skill levels th thack for geopolitical motives.

According to CrowdStrike, a cybersecurity consultancy, geopolitical developments have become the "most important drivers for cyberattacks," with the latter now firmly part of the "global threat landscape."[98] Adds Kevin Mandia, CEO of FireEye, another cybersecurity firm: "It does not seem reasonable to expect the majority of the private sector to defend itself from military cyber attacks. We do not expect a homeowner to prevent a military unit from breaking into their bedrooms, so why should we expect companies to prevent or detect similar attacks in cyberspace?"[99]

Dealing with this reality has implications for how federal agencies should work with the private sector and for the appropriate allocation of public resources. The potential for nation-state attacks also has implications for liability protection for utilities in the event of a cyberattack; for sharing classified information with utilities; and for interindustry and interagency coordination. As the GAO reported, the Department of Defense's own infrastructure is vulnerable to cyber-physical attack.[100] Rather than focus on "Climate Change Adaptation Road Maps,"[101] the Pentagon should prioritize helping the private sector secure and defend America's critical electric infrastructure. The Defense Advanced Research Projects Agency announced plans in January 2016 for a $77 million, four-year program to help utilities detect cyberattacks; but given the scale and complexity of the challenges, it is only a small step.[102]

Tech titans, including Facebook, Google, Apple, and Microsoft, have pledged to help advance the deployment of "green" and smart grids.103 They should also acknowledge, and help resolve, the cybersecurity challenges associated with such initiatives. The foundational responsibility for solutions originates with the technologies' providers, not

the users in the industrial and utility sectors. Similarly, investors and policymakers should explore ways to encourage greater focus on innovative venture capital in cyberphysical security—which accounts for less than 1 percent of total venture-capital investment.[104]

As this report argues, if U.S. state and federal cyberphysical security policies are to become coherent and effective, they must be anchored in acknowledging three realities: (1) the rush to make U.S. grids greener and smarter also increases their cyberphysical attack surface; (2) there are two radically different classes of cyber threat: private hackers and nation-state (or nation-sponsored) hackers; and (3) evolving cyberphysical threats are unlike other physical-security issues that utilities have heretofore faced.

Sound grid-cybersecurity policy would therefore:

- Avoid top-down, one-size-fits-all legislation.
- Slow—and, in some cases, halt—smart- and green-grid transformation that increases the attack surface until adequate cybersecurity features are available and incorporated.
- Reallocate grid budgets to increase funding for security, resilience, and reliability, and require cybersecurity metrics as part of pre-deployment requirements for green and efficiency programs.
- Boost utility-sector collaborative engagement with federal cybersecurity programs, especially those of the U.S. Department of Defense.
- Encourage private-sector-led cybersecurity technology research, development, and deployment, so that companies on the front line can move at the speed of innovators, not bureaucrats.
- Ensure that policies, mandates, and regulations in cybersecurity are based on overall objectives—rather than being prescriptive and subject to becoming rapidly obsolete.

8 ENDNOTES

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