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**The missing ingredient in American infrastructure repair**

By Neil Padukone and Justin Talbot-Zorn

In their dueling speeches in Detroit recently, Donald Trump and Hillary Clinton presented radically different visions for the U.S. economy.

Yet, for all their disagreement, the candidates found common ground on one high-profile economic issue: infrastructure. With this week's proposals, the two candidates were actually struggling to outdo each other on who would do the most to fund public works.

This agreement on infrastructure is long overdue. Every single day in New York, Washington, and other cities, glitches in decades-old and underfunded subway systems keep thousands of people delayed underground.

More than 63,000 bridges throughout the country are in need of major repairs, and at least 32% of roads are in poor condition. And it's not just transportation. As Flint tragically revealed, infrastructure failures can devastate communities and actually ruin lives.

The glimmerings of bipartisan agreement are good news. But it’ll take more than politicians’ token interest — and even financial commitment — to solve these problems. Infrastructure upgrades are tough. They can be disruptive to the public, entail cost overruns, and take years to complete, extending past the electoral cycles that allow politicians to claim credit for success. Fixing U.S. infrastructure will require two ingredients that are often in short supply: patience and political will.

In decades’ past, America had powerful constituencies that would fight for infrastructure projects and see them through to completion: the engineers that created and maintained the technologies that were deployed on projects, the workers and unions that powered the projects, and the firms that built equipment and needed reliable ways to move goods and materials.

This manufacturing coalition, starting from the New Deal, brought us the roads, bridges, trains, and utilities that we still rely on today. It’s true, they often had selfish reasons for promoting infrastructure investments. But they nonetheless served the public interest.

With the loss of domestic manufacturing over recent decades, we no longer have the built-in political will that supported infrastructure. We’re also left without a crucial source of technological innovation, which is vital for infrastructure improvement.

The only way to nurture important technologies — like smart meters that automatically regulate energy use, computer-based safety features for railways, or more efficient ways of building and maintaining infrastructure — is with a serious domestic manufacturing base.

While we often assume it's easy to conceive a new idea in Ohio and manufacture it in China, real innovation requires complete ecosystems where the conception of ideas, their production, and their improvement all happen together.

Think of it this way: If you're overseeing the production line on a wind turbine or train car, you can see bottlenecks or opportunities in the process and come up with ways to improve it. And if you're physically creating a product, you can experiment with how different components cross-pollinate to create something new.

That’s one reason Germany, with its extensive manufacturing base, not only regularly upgrades its infrastructure but also pioneers next-generation technologies, from solar and wind power to the most reliable highways and rail systems.

With the loss of so much domestic manufacturing in the U.S., it’s no surprise that we’re struggling to innovate or even maintain American infrastructure. While the next president should keep up the promises to boost investment, to repair our roads, bridges, water systems, and broader public works, these promises alone won’t get the job done.

To rebuild infrastructure, we need to restore the manufacturing base. There’s no shortage of ideas for doing so.

For starters, ending incentives for offshoring would save U.S. manufacturing jobs and directly help build and maintain our infrastructure. The big and bulky products required for public works — rail cars, smart computer systems, steel girders — are expensive and time-consuming to ship across oceans. Smart tax policies can go a long way toward bringing their production back to our borders.

To restore the production base, we also need to rebuild interest in manufacturing careers. In 2009, just 18% of new university graduates completed a bachelor’s degree in technical areas like engineering, compared to 24% in the 1990s.

In popular media, Americans have been inundated with the wrong-headed message that good careers are only based in an office and result from classroom study, forgetting that apprenticeships on a shop floor or project site can be as or more rewarding. Policymakers can rebuild the manufacturing workforce by implementing simple but important ideas, like apprenticeships and shop class in schools.

Finally, we need innovation policy that helps turn high-level research into useful products we can make in America. As Sridhar Kota, a manufacturing expert at the University of Michigan and former adviser to President Obama, puts it, when it comes to “R&D,” we need to reconnect the “R” with the “D”. This means investing in practical applications of cutting edge science research that can be used for infrastructure like smart sensors, alternative energy sources, and even hyperloops.

Bipartisan agreement on infrastructure is an exciting development. But if we’re really going to fix our roads, bridges, power grids, and water systems — we need to think bigger. We need to restore American manufacturing.

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**Plan today for the infrastructure of tomorrow**

Domenico Grasso and Sheila Tobias

Both major-party candidates for president have released "bold" infrastructure plans to build the "next generation of roads, bridges, railways, tunnels, seaports, and airports."

Hillary Clinton's plan totals $275 billion over five years, plus an additional $225 billion in loans and loan-guarantee programs. Donald Trump's plan calls for an outlay of $800 billion to reverse "decades of decay in the nation's public transportation arteries and create millions of jobs." These are bold plans - but not bold enough. The fact is, the infrastructure of the future is not going to be the infrastructure of the past.

The new infrastructure has to deal not only with capturing new opportunities but also with foreseeing and addressing new challenges. Rebuilding the infrastructure will not be about technology alone, but about building integrated systems that take advantage of humanity's singular capacity for creativity and expression in all aspects of our lives and society.

In the "super smart societies" that engineers and other planners are anticipating, we will have to not only rebuild but rethink our infrastructure. That's because information and data are already driving 80 percent of our economy, and tomorrow's energy sources might not look like today's. Here are a few examples:

The hydrogen economy is going to need an infrastructure to support it; recharging stations for electric cars are already here; semiautonomous vehicles will change the way roads are built, as well as highway signage (interacting with cellphones and automobiles directly instead of people).

On food systems, people in cities are looking more to local farm-to-plate community-supported agriculture, where consumers can buy a share of a farm, changing food-delivery patterns that drive much of today's transport of food production.

"Smart cities" will not only be outfitted with myriad sensors but will also be complex in different ways from now: bicycle-friendly, featuring parklike downtowns like the New Cleveland designed in time for the Republican convention.

Before we rebuild water sources and water-treatment plants, shouldn't we look at wastewater - no longer just a flow-through for treatment - as a mining resource, for minerals and other uses?

Since the last infrastructure was designed and built, cybertechnology has greatly changed the way we live. The smartphone was introduced only 10 years ago, but think about the new sharing economy that has emerged in just that short time. A device as small as a telephone can now enable us to handle more personal and professional tasks without having to leave our homes or offices.

As we depend more on technology, some are taking the opportunity to divest themselves of their own personal responsibility. For example, the use of GPS navigation has caused some motorists to drive blindly into lakes while following automated commands rather than using common sense. Clearly, even when we automate, we cannot abdicate responsibility for ourselves and others. To counter the mind-dumbing effects of an overprescribed and controlled society, a few cities in Europe are reducing the number of road signs (!) to force drivers to use their judgment and pay attention to their environs.

And then there is the demographic challenge - for some nations more than others. The Japanese, facing the need to care for an aging population, are heavily investing in robotics-based care. And now that we have the capacity to bring lectures, encyclopedias, and even scientific experiments directly into our homes, shouldn't we rethink the entire educational infrastructure to determine how to make these opportunities equally available to everyone?

Yes, our infrastructure is crumbling, but we can't just replace it with the same type of roads, water plants, and schools, ignoring advancements in technology and other developments since the existing infrastructure was created.

Rebuilding our next-generation infrastructure is not only about shovels in the ground. We must start by investing in a new breed of engineers who think holistically, are extraordinarily innovative, and will work with economists, attorneys, policy analysts, and journalists to support life and happiness in the 21st century.

Our next president must not miss this opportunity. Rather, our nation's new leader must have the thoughtfulness and foresight to partner with higher-education leaders and invest heavily in educational paradigms that will help engineers address the complexities of an uncertain and unforeseen future.

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