

# Challenges of our nation's aging infrastructure

The pressing need to maintain critical systems





# Introduction

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There is a lot of buzz in the media about America’s aging infrastructure and the government’s pledge to rebuild our roads and rails.<sup>1</sup> The problem is widespread, impacting not only our transportation network, but also water systems, communications networks and the energy grid. Current proposals to rebuild the infrastructure focus on the use of private funds to help finance a significant share of the reconstruction effort.<sup>2</sup> Whether Public-Private Partnership (P3) construction projects will ultimately be able to sway the pendulum remains to be seen.

The U.S. infrastructure is outdated, costing both the government and private industry millions in repairs, business interruption and supply chain risks. The American Society of Civil Engineers estimates that by 2020, “aging and unreliable” infrastructure will cost American businesses \$1.2 trillion.<sup>3</sup> While there are ways to transfer and mitigate the risk — business interruption insurance and supply chain resilience programs — these are not holistic solutions. Overall, investment in infrastructure is needed to limit further deterioration of critical systems.

Infrastructure provides the foundation of our economy and quality of life. Investing in aging infrastructure, therefore, is essential to supporting healthy, vibrant communities. A report from the Economic Policy Institute reiterated the link between infrastructure investment in the U.S., a boost in gross domestic product and the creation of hundreds of thousands of new jobs.<sup>4</sup>

However, the reverse also can be true: A failure to prioritize infrastructure needs can damage the economy and present myriad challenges to a country, its citizens and businesses. Overall, investments in the maintenance and upgrade of critical infrastructure have been insufficient over the last decade to maintain quality throughout the developed world, particularly in the U.S. The World Economic Forum published a report that places the U.S. 12th among countries in terms of infrastructure quality and weakening.<sup>5</sup> A report from the American Society of Civil Engineers states that infrastructure deficiencies affect both the quality and quantity of jobs in the U.S. economy and, as a result, spur losses in disposable income. It predicts that from 2016 to 2025, each U.S. household could incur an annual average of USD 3,400 for losses connected to underinvesting in aging infrastructure. In addition, losses to the national economy due to infrastructure investment gaps is projected to be over USD 7 trillion in business sales from 2016-2025, while loss in GDP is expected to be USD 3.955 trillion during the same period.<sup>6</sup>

# Infrastructure: the impact of four key sectors

There are four main areas of critical infrastructure that could impact economic activity:

- Transportation
- Energy
- Water
- Communications

The Oxford English Dictionary defines infrastructure as the “basic physical and organizational structures needed for the operation of a society or enterprise.” That definition could potentially encompass most — if not all — sectors of an economy.

Taking it a step further, critical infrastructure can be defined as infrastructure elements that, if significantly damaged or destroyed, would cause serious disruption of the dependent system or organization. Critical infrastructure includes the production, transmission and distribution of electricity, gas and oil; telecommunications; water supply; agriculture; food production and distribution; public health services; transportation systems; financial services and security services.

Here we will focus on four areas of infrastructures critical for economic activity and the failure of which would have great economic impacts, including those resulting from business interruption. These key sectors include **transportation, energy, water** and **communications**.





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## Transportation

Transportation infrastructure, including roads and bridges, rail, ports and airport infrastructure, plays a vital role in our economy, assuring the transport of goods and connecting people with jobs, medical facilities, schools, recreation and more.

Road infrastructures are a key priority, given the significant distances and difficulties involved in overseeing and maintaining such extensive networks. More than four million miles of public roadways support many more millions of vehicle miles.<sup>7</sup> U.S. businesses spend USD 27 billion in additional freight costs due to poor conditions of roads and other surface transportation infrastructure.<sup>8</sup> Companies also incur additional costs for coverage, such as property, workers' compensation, and supply chain and business interruption insurance due to the increased risks associated with aging infrastructure.

The U.S. Interstate Highway system, which carries more than 25 percent of all vehicle miles of travel, is critical to mobility, yet represents just 2.5 percent of all roadway miles in the nation. Since funding of the Interstate system was approved in 1956, annual vehicle miles of travel in the U.S. have increased by 387 percent to about three trillion miles driven. Most of the Interstate Highway system is more than 50 years old, and the U.S. Department of Transportation puts a price tag of USD 189 billion on addressing needed repairs and improvements.<sup>9</sup> Annual spending on the nation's Interstate Highway system is estimated to be USD 20.2 billion, which is approximately 61 percent of the amount needed annually to make needed repairs and improvements on interstate roadways.<sup>10</sup> A state-by-state assessment of public roadway conditions from the Department of Transportation found that, for more than 40 states, the percentage of public roads in poor or mediocre condition ranged between 36 and 65 percent. Two states, Connecticut and Illinois, had ratings as high as 73 percent.<sup>11</sup>

According to the American Society of Civil Engineers, 32 percent of America's major roads are in poor condition. One out of every five miles of highway pavement is also in poor condition.<sup>12</sup> Under-investing in this infrastructure led to ever-increasing congestion as highway system expansion has failed to keep pace with usage.<sup>13</sup>

A similar predicament exists for U.S. bridges. Urban bridges, an indispensable link for millions of commuters and freight on a daily basis, are decaying more rapidly than rural bridges. One in nine bridges in the U.S. is rated structurally deficient and the average age of the nation's 614,387 bridges is over 50 years old.<sup>14</sup> Tragic failures, such as the collapse of the eight-lane I-35W Highway Bridge in Minneapolis that resulted in 13 deaths and 145 injuries, and the 2015 collapse of a bridge on Interstate 10 in Southern California that stranded hundreds of motorists, underscore the need for urgent repair and replacement of this vital yet aging infrastructure.



Allowing bridges to remain in serious need of repair can lead to the sudden closure of a critical transportation link or, far worse, a collapse that results in lives lost and a major economic impact to the affected region. While billions have been spent annually on bridge construction, rehabilitation and repair in the last 20 years, current funding levels are not enough to repair or replace the nation's large-scale, urban bridges, which carry a high percentage of the nation's traffic. Currently, 56,007 bridges out of the 614,387 bridges in the United States are rated as structurally deficient, which equates to 9.1 percent of the bridges in the U.S.<sup>15</sup> Of the 250 most heavily traveled bridges that need repairs, 85 percent were built before 1970.<sup>16</sup>

The Federal Highway Administration (FHWA) calculates that more than 30 percent of existing bridges have exceeded their 50-year design life, meaning that maintenance, repair and rehabilitation programs will require significant investment in upcoming years.<sup>17</sup>

Beneath many of those bridges are the nation's inland waterways and rivers, transporting more than 566 million tons of freight via 12,000 miles of commercially navigable channels. The freight is valued at more than USD 152 billion. In many cases, the inland waterways system in the U.S. has not been updated since the 1950s, and the majority of the 239 locks are well past their 50-year design life.<sup>18</sup> However, while port terminal facilities themselves seem to have benefited from significant new investment and improvements, the connections to the ports — the navigation channels leading to the docks, as well as the landside connections — need to be brought up to modern standards. The terminals require navigable waterway maintenance and dredging, along with rail and highway connector improvements to function optimally. Without these corresponding improvements, the terminals will see limited benefits in terms of moving additional goods. The American Society of Civil Engineers estimates total capital investment needs over the next 20 years at about USD 18 billion.<sup>19</sup>

With more than 90 percent of world trade moving by sea<sup>20</sup>, even companies operating domestically in landlocked regions have some part of their supply chains traveling by ship.<sup>21</sup> For example, each year more than 4,000 ships call at Los Angeles and Long Beach Ports, which serve as intermodal transfer points for tens of thousands of truck trips a day. These ports could be physically untouched by a catastrophic event like an earthquake, but become obsolete if truck traffic is cut off because of damaged highways. The supply chain would be broken.

Although airports face similar problems associated with inadequate maintenance and capacity expansion, the risks associated with these infrastructure assets are likely to be more closely managed and better understood. In addition, airports have more clearly defined income streams while road and rail assets are more likely to be maintained and/or subsidized by government.

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## Energy

The U.S. energy infrastructure consists of three interrelated segments: electricity, oil and natural gas. Energy infrastructure is described by the U.S. Department of Homeland Security as an “enabling function” across all critical infrastructure sectors.<sup>22</sup> Most industries rely on the energy sector to provide the power needed to run their businesses.

Investment in new and maintained infrastructure is currently insufficient to meet the growing need. Energy consumption in the U.S. has grown from 500 billion kilowatt hours (kWh) in 1950 to four trillion kWh in 2015.<sup>23</sup> In fact, Americans constitute five percent of the world’s population but consume 18 percent of the world’s energy.<sup>24</sup> The availability of energy in the form of electricity, natural gas and oil will become a greater challenge as the population increases, and with it, the demand for energy.

Aging equipment has resulted in an increased number of intermittent power disruptions, as well as vulnerability to cyber attacks. Power outages put public safety at risk by potentially shutting down telecommunications networks, financial services and water supplies. Additionally, when energy infrastructure is networked, the failure of one element of infrastructure can have widespread impact affecting not only the power grid, but transportation and water systems as well.

The average cost of a one-hour power outage is just over USD 1,000 for a commercial business in the U.S., but even a very short interruption of a second or two can cost USD 733.<sup>25</sup> The electric grid’s inability to withstand weather-related outages costs the U.S. economy between an average of USD 18 billion and USD 33 billion each year.<sup>26</sup>



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Changing perceptions toward the environment, and particularly fossil fuel consumption, have impacted energy infrastructure. In the U.S., environmental restrictions caused dozens of coal-powered plants to close because of federal air pollution regulations. By 2015, 200 plants had been shut down.<sup>27</sup> While this was implemented to provide important long-term environmental benefits, there is still a pressing need to evaluate outdated power plants as wind, solar and nuclear alternatives get up to speed with demand.

Alternative power sources, such as nuclear power, pose their own challenges. The U.S. is currently constructing new reactor plants for the first time in over 30 years,<sup>28</sup> and as older reactors are being phased out, their parts are being salvaged to extend the life of reactors that will stay in production. The extension of plants beyond their useful life brings with it a degree of uncertainty and risk.

Failure to maintain energy infrastructure can have disastrous consequences. In 2010, the explosion of a gas pipeline in San Bruno, California resulted in the deaths of eight people, destruction of 38 homes, as well as additional injuries and property damage. The pipeline had been installed in 1956 and was in need of maintenance and repair.<sup>29</sup> It was not built to withstand the pressure testing of newer lines.

Though public pressure and government action has led to some new investment, the U.S. energy infrastructure needs for the period 2015-2016 was estimated to be only 81 percent funded. This leaves a gap of an estimated \$177 billion in needed funds to fully maintain this infrastructure.<sup>30</sup> In addition to breakdowns associated with aging infrastructure, this gap in investment may leave critical energy infrastructure at risk of cyber attack and related losses, including property damage, bodily injury and business interruption.





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## Water

Water is a fundamental health and economic resource. The U.S. uses about 80 percent of the nation's entire water consumption for crop irrigation; that number rises to 90 percent in the West.<sup>31</sup> Beyond the demand for water in the agriculture industry, water is an essential element for the country's trade, domestic use and public amenities. And then there is the nation's sewage disposal system, which supplies critical sanitation needs. With much of it dating back to the 19th century, parts of the U.S. sanitation infrastructure are not only nearing the end of their useful life, but are outright failing in some parts of the country. There are an estimated 1.2 million miles of water main pipes in the U.S and 240,000 water main breaks per year.<sup>32</sup> Public spending on drinking and wastewater projects declined by 23 percent from 2006 to 2013,<sup>33</sup> further exacerbating the problem. Broken water mains can damage roadways and structures and hinder fire control and other emergency efforts. Unscheduled repair work to address emergency pipe failures may cause additional disruptions to transportation and commerce. In 2014, a 90-year-old water main belonging to the city of Los Angeles broke at the University of California, Los Angeles and caused millions of dollars in damages.<sup>34</sup>



A look at New York City provides another clear example of the stresses being put on an aging water system. The city's freshwater infrastructure has 8.4 million users who consume over one billion gallons a day of fresh water and produce 1.3 billion gallons of wastewater.<sup>35</sup> This vital system is now of considerable age, with 46 percent of New York's 6,785 miles of water pipes built prior to 1941 and 1,000 miles are over 100 years old.<sup>36</sup> Suboptimal construction is a problem: 4,000 miles are constructed of either unlined or cement-lined cast iron. This is inferior to the flexible ductile iron used today and prone to leaks as a result of internal corrosion. Equally noteworthy, about 4,000 miles of sewer pipes are made of vitreous clay, which is more susceptible to cracks and blocking and requires vigilant monitoring and repair.<sup>37</sup> Over 50 percent of pipes are also less than 12 inches in diameter, which makes them four times more likely to break.<sup>38</sup> Water main breaks have become a regular occurrence in the city. In 2013, more than 400 breaks occurred across the five boroughs; the figure climbed to 513 in 2014<sup>39</sup> and included a major break that flooded streets and subways on 13th Street in Lower Manhattan, causing significant business interruption.

Dams represent another area of concern. By 2025, 70 percent of dams in the U.S. will be over 50 years old.<sup>40</sup> These dams were built with the best engineering and construction standards of the time. However, many are not expected to safely withstand current predictions of large floods and earthquakes. Dam failures not only can threaten public safety, but also can create losses in millions of dollars. The 2010 Lake Delhi dam failure in Iowa caused massive flooding and cost an estimated USD 50 million in damages and USD 120 million in economic losses.<sup>41</sup> The dam was constructed between 1922 and 1929.<sup>42</sup>

Water wastage presents a significant problem, too. Because water is readily available from the tap and virtually taken for granted, it is used once and then flushed away. This rate of waste adds to the workload of an aging and poorly maintained water infrastructure.

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## Communications

The communications sector includes physical properties such as landline, wireless, satellite, cable and broadcasting, as well as services that include internet content and routing, information services and cable television (CATV) networks. In addition, publicly and privately owned cyber/logical assets are inextricably linked with these physical communications structures.

The services offered or performed by the communications sector are critical components of the business and government processes that are fundamental to our way of life. These services include electricity, banking and finance, emergency services and government continuity of operations (COOP).<sup>43</sup> A breakdown in service can also create additional vulnerabilities to the network as a result of cyber attack.

The communications infrastructure merits few immediate concerns relative to age, but there is considerable interdependency between this sector and other critical infrastructures, in particular the industry's dependence on electrical power. Electricity powers the communications systems equipment, the central control/management/operating systems and even the environmental control systems surrounding the communications equipment.

A number of large-scale power outages, including the 2003 Northeast region blackout and Hurricane Katrina in 2005, have highlighted the strong interdependencies of the power and communications sectors.

Access to water and the ability to handle waste water can likewise be considered critical dependencies for communications providers. In most cases, the environmental control systems for communications facilities rely on fresh water for air conditioning and other environmental services. Similarly, the ability to handle waste water from chillers or coolers is also important.

As such, aging infrastructure concerns relating to electric power supply and distribution and water infrastructure have the potential to directly impact the communications sector. A breakdown in service as a result of such interdependencies can also create additional vulnerabilities to the network from potential cyber attack.<sup>44</sup>

For additional details related to such cyber risks, The Atlantic Council and Zurich Insurance Company Ltd. collaborated on the report, **“Beyond Data Breaches: Global Interconnections of Cyber Risk,”** to better prepare governments and businesses for the cyber shocks of the future. Water and electric infrastructure may be particularly vulnerable to cyber breaches due to the age of the systems and the interconnected dependence on these services. But other infrastructure of critical importance may be equally vulnerable, including transportation, energy and communications.

# Funding structures: Public-Private Partnerships



Traditionally, infrastructure projects have been publicly funded; a public works authority would award the construction of a project designed by the Public Works Administration (PWA) to a private firm, which would build the project. After receiving the agreed payment, its contractual link with the project would end.

One concern with the traditional arrangement is that, in most cases, the separation between construction and operation gave the builder little incentive to account for life-cycle costs, such as future maintenance and operations costs, beyond what was specified in general construction standards for infrastructure projects. Combined with the fact that governments have tended to allocate financing to new projects rather than to maintaining existing infrastructure, this has contributed to an ongoing stop-go approach to project maintenance, resulting in higher costs and lower quality standards.

Public-Private Partnership (P3) construction projects can improve the efficiency of infrastructure provision by bundling maintenance and operations with construction of the infrastructure project. Because the private partner builds, operates and maintains the project, the incentives for durable construction and efficient maintenance and operation are aligned.

With public provision, a construction firm minimizes building costs subject to design characteristics. In P3s, by contrast, the private firm minimizes life-cycle costs, which include building, operations and maintenance costs.

Despite the success of P3 construction projects in other parts of the world, they have only begun to gain in popularity in the U.S. in recent years. In fact, the U.S. still depends almost exclusively on the government for its public transport infrastructure (with the important exception of railroads).

P3s in Europe increased six-fold, on an annual basis, between 1990 and 2006. Whereas the UK financed USD 50 billion in transportation infrastructure via P3s between 1990 and 2006, the U.S., an economy more than six times as large, financed only about USD 10 billion.<sup>45</sup> However from 2005 to 2014, 48 infrastructure P3 transactions in the U.S. with an aggregate value of USD 61 billion reached the formal announcement phase. Of the 48 deals, 40 transactions — or more than 80 percent — successfully closed.<sup>46</sup>

# Increasing awareness and reassessing risk exposures



**In an increasingly global economy, the chains linking suppliers, manufacturers, distributors and retailers are longer and more complex than ever, and all of them rely on a delicate web of infrastructure to keep the wheels of commerce moving.**



Aging and poorly maintained infrastructure can expose the public to many types of risks. The most obvious are traditional risks, such as bodily injury and property risks. As infrastructure deteriorates, there is an increased risk of physical injury from accidents caused, for example, by poor surfaces or faulty equipment. Furthermore, the risk of damage to property — for instance, from water damage caused by a burst pipe or attritional damage to commercial fleets from potholes — also will increase over time. For businesses, there is a danger when these risks overlap, such as when bodily injury affects reputation or vehicle damage causes a breakdown within an organization's supply chain.

Aging infrastructure can create additional, less obvious risks as well.

## **Emerging risks**

Emerging risks can cause business interruption as a consequence of obsolete and outdated systems and equipment, and as load capabilities become unable to meet the capacity required. Business interruption insurance may be advised to cover unexpected business closures.

In an increasingly global economy, the chains linking suppliers, manufacturers, distributors and retailers are longer and more complex than ever, and all of them rely on a delicate web of infrastructure to keep the wheels of commerce moving. If these links suddenly dissolve, disruptions of mounting severity could follow. A study of Zurich's claims on a global basis shows that Business Interruption (BI) is an increasing percentage of its large property claims over USD 5 million, growing from 21 percent in 2002 to 44 percent in 2013.

A mishap suffered by a supplier on the other side of the world can shut down an organization's operations as surely as if it happened in its own facility. For the past six years, more than 75 percent of companies reported having supplier disruptions, with half suffering more than one break per year.<sup>47</sup> Historically, supply chain business interruptions can disrupt sales and increase the cost of doing business. These impacts have been known to last up to two years, and many companies never fully recover from supply chain disruption.

Other costs are difficult to measure, yet potentially more devastating overall: management time consumed in solving disruption issues, permanent client loss after customers have been forced to find alternative sources and damage to reputation.

Businesses could benefit from reassessing their plans to ensure they are completely updated to current standards and have been stress-tested to see if they actually respond as designed. Companies have traditionally focused their continuity plans internally, but the rapid shift to outsourced processes, long supply chains and just-in-time operations means that companies must also consider far-reaching continuity plans that involve service providers such as suppliers and logistics companies. Currently, only 17 percent of companies have continuity plans with their supply and logistics service providers,<sup>48</sup> which suggests that infrastructure problems impacting their providers could have a greater impact on their own business resilience and profitability.

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This makes it worthwhile to undertake a supply chain risk assessment. However, if a supply chain has worked well over a long period of time, it can be difficult to recognize the importance of business continuity plans. A major supply chain risk, therefore, is that organizations aren't recognizing the importance of making an assessment.

To help companies empirically assess their risks to disruptions in the value chain from aging infrastructure and other exposures, Zurich's Emerging Risk Group teamed up with Manchester Business School (now Alliance Manchester Business School) and the University of Bath in the UK to develop a unique loss-event database, which holds supply chain disruptions that occurred over a span of 12 years around the world. The team has already determined two broad factors that will continue to play a major role in preventing supply chain stability: natural disasters and logistical failures that strike indiscriminately across industrial sectors.

This further illustrates a critical area of interconnectivity. Aging infrastructure is less able to withstand potential damage from natural disasters, and may clearly contribute to an increasing frequency of damage and financial impact due to logistical failures as a result of such disasters. These cascading effects demonstrate why it's more important than ever to map out the value chain from end to end, including interdependencies.

### **Systemic risks**

Systemic risks are also a problem, given the interconnected nature of both individual infrastructure systems and the system as a whole. These can be triggered by external shocks, such as natural catastrophes or cyber attacks.

Infrastructure is subject to considerable systemic risk and that risk will heighten as structures age and deteriorate. This could be within one type of critical infrastructure, but it could also involve interconnected failures across several different forms of infrastructure types. Communications infrastructure, as has been seen, relies heavily on electricity to function, while many energy infrastructures require constant and large-scale water supplies.

In the future, replacement technologies are likely to be subject to even higher systemic risk — for example, a security breach in outdated communications infrastructure could compromise the operations of smart grid infrastructure, an electrical grid including a variety of operational and energy measures. It is important that businesses invest in research and development to help offset the impact to infrastructure from these interlinked risks.

## How you can determine your risk

1. How vulnerable is the infrastructure? When was it built and how has it been maintained?
2. How likely is a failure? Is there qualitative or quantitative analysis that can help determine the probability of a failure?
3. What are the potential consequences of the infrastructure failing? How long would it take to get the system back up?
4. Has a checklist been developed that identifies actions to be taken should a failure occur?
5. What improvement criteria have been established to help reduce the risk of infrastructure failure? How long will it take to put into place?

## Political and regulatory actions

Political and regulatory actions create additional emerging risks for those operating, maintaining and constructing infrastructure risks. For instance, after the collapse of the I-35W bridge in Minneapolis, the state of Minnesota sued Jacobs Engineering Group, Inc., the successor of Sverdrup & Parcel, the firm that designed the bridge in the 1960s. The case, *Jacobs Engineering Group, Inc. v. Minnesota*, is considered a landmark construction law case. After the bridge collapse, the Minnesota legislature created a compensation fund for victims and nullified a statute of limitations that would have prevented the state from seeking damages. The Minnesota Supreme Court upheld the action, ruling that the state could use its compensation fund as a means to retroactively revive claims against the companies that designed and constructed the bridge. Jacobs' appeal was turned down by the U.S. Supreme Court. The company eventually paid USD 8.9 million in November 2012 to settle the suit without admitting wrongdoing.<sup>49</sup>

Such retroactive actions create additional difficulty in assessing liability when state and governmental entities pursue avenues like these.

Long-term financial viability is a concern with projects tasked with repairing aging infrastructure and launching long-term construction to replace older structures. These projects will cost in the hundreds of millions, and in some cases exceed the billion dollar mark. The terms can be three to 10 years in duration. When considering the risk associated with such a long-term investment that is usually backed in whole or part with a governmental entity, it is always a concern that the funding continues and that there are no legislative changes that could impede funding or project completion. Weather changes, political changes, catastrophic events, and more can impact these exposures over the long term in ways that are difficult to foresee. Often, surety bonds are used to help minimize the risks associated with a construction project and provide greater assurance of a project's completion



# Conclusion

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The risks of an aging infrastructure include traditional exposures such as property and casualty risks, business resiliency challenges, and systemic risks stemming from interconnected nature of infrastructure and long tail liability. While the risks and challenges posed by the aging U.S. infrastructure are significant, there are nonetheless real opportunities for public entities and private industry to become part of the solution, helping to facilitate the vital repairs, maintenance and creation of critical infrastructure.

These entities must work together to assess whether an infrastructure project truly meets societal needs and the steps that need to be taken to move forward. In other words, where aging infrastructure is no longer sufficient, it is not always a case of directly replacing that infrastructure, but instead replacing it in a way that meets present-day requirements and creates a robust investment for the future.

We can't afford to sit back and watch as our infrastructure falls apart.



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