

Senior Scholars at Queens  
Speaker Series

April 9, 2021

# US Infrastructure: the Future is Now

presentation by

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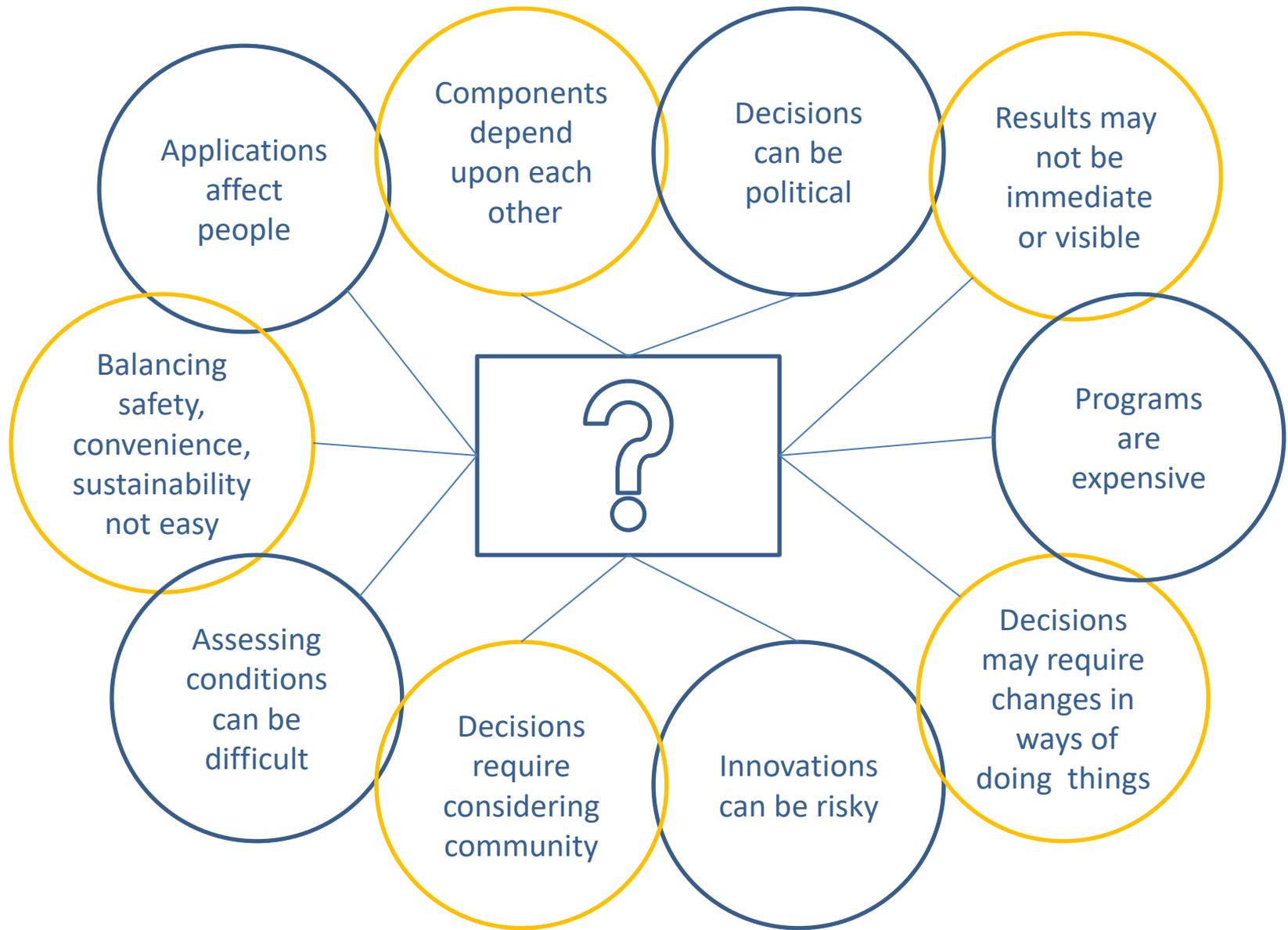
# Point – Counterpoint on U.S. Infrastructure

**Yes, there is a serious problem:** The American Society of Civil Engineers (ASCE) “2021 Report Card on America’s Infrastructure” [1] gives the US infrastructure an overall grade of C-. This grade is an improvement from the D+ grade in 2017 and 2013, but the report still points out many problems, as described in slides #4 - #8 that follow.

Other organizations describing our infrastructure as needing immediate attention include the Council on Foreign Relations [12] and the U.S. Chamber of Commerce [13].

**No, there is not a serious problem:** “America doesn't have an infrastructure crisis,” states James Pethokoukis in his article in “The Week” at msn.com [2]. Even though “public domestic investment as a share of the economy has fallen by more than 40 percent since the 1960s, that doesn't mean U.S. infrastructure is crumbling.” He goes on to say that a 2019 paper by the Brookings Institution [3] reported our infrastructure to be in its best shape in decades.

# Prioritizing U.S. Infrastructure Decisions



## Drinking Water

There is a water main break every 2 minutes and an estimated 6 billion gallons of treated (drinking) water are lost every day.



## STATUS

## Airports

From 2017-2019 passenger air travel increased 27% while flight service increased only 5%, contributing in part to ~96 million delay minutes for airline passengers in 2019.



## Roads

Growing wear and tear on our roads have left ~43% of our public roadways in poor or mediocre condition. Motorists pay over \$1,000 every year in wasted time and fuel. While traffic fatalities have declined, over 36,000 people still die on our roads every year.



## Levees

There are ~40,000 miles of levees across the U.S., but the location and condition of ~10,000 miles of those levees are unknown.



## Bridges

Of more than 617,000 bridges in the U.S., and 46,154 are considered structurally deficient. A recent estimate for the nation's backlog of bridge repair needs is \$125 billion.



## STATUS

## Dams

The Association of State Dam Safety Officials estimates there are over 91,000 dams in the U.S., with a doubling in recent years of the number classified as “high-hazard-potential”. The number of deficient “high-hazard-potential” dams exceeds 2,300.



## Energy

Annual spending on high voltage transmission lines grew 35% over 5 year period to 2017 and spending on distribution systems grew 54% over the past two decades. Still, there were 638 transmission outage events reported from 2014 to 2018.



## IT/Broadband

65% of counties have average connection speeds lower than the FCC's definition of broadband. An estimated 1/5 school-aged children lack the high-speed internet connection needed to access lessons.



## Hazardous Waste

~35 million tons of hazardous materials are managed annually in the U.S. at ~1,300 Superfund sites where cleanup activities are either incomplete or not yet begun. ~60% of all nonfederal Superfund sites are located in areas that may be impacted by flooding, storm surge, wildfires, or sea-level rise.



## STATUS



## Parks

In 2017, people spent \$887 billion on outdoor recreation and parks, directly supporting 7.6 million jobs. Despite their increased popularity, investment in parks is lagging. State parks and local parks face a \$5.6 billion and \$60 billion deferred maintenance backlog, respectively.



## Waterways

The U.S. inland waterway system reports a \$6.8 billion backlog in construction projects and reports lock closures totaling 5,000 hours between 2015 and 2019. The USDoA estimates delays cost ~\$739 per hour for an average tow.



## Ports

The nation's ~300 coastal and inland ports supported 30.8 million jobs in 2018 and 26% of the total GDP. There is a funding gap of \$15.5 billion for waterside infrastructure such as dredging, with additional billions needed for landside infrastructure, such as connector pavements; only 9% are in good condition.

## Rail

Approximately 140,000 rail miles are operated by freight railroads. Amtrak operates a passenger network of over a 21,400-miles. Freight invests on average over \$260,000 per mile, obtained through shipper fees, but passenger rail requires government investment currently facing a repair backlog at \$45.2 billion. Along the Northeast Corridor, infrastructure-related issues cause ~328,000 train-delay minutes annually.



## Schools

~53% of public schools report the need to update or replace building systems. ~33% report the use portable buildings with 45% in poor or fair condition. State capital funding for schools was down 31% in fiscal year 2017 compared to 2008.

## Municipal Solid Waste

The U.S. produced approximately 268 million tons of municipal solid waste (MSW) in 2017. Overall, 53% of waste is deposited in landfills, 25% is recycled, 10% is composted, and 13% is combusted for energy. Growing challenges include emerging contaminants found in landfills.



## Storm Water

Impervious surfaces in cities and suburbs exacerbate urban flooding, resulting in \$9 billion in damages annually. Nearly 600,000 miles of rivers and streams and more than 13 million acres of lakes, reservoirs, and ponds are considered impaired by storm water runoff. Federal funding leaves a growing annual funding gap of \$8 billion just to comply with current regulations.



**STATUS**

## Transit

45% of Americans have no access to public transit. Much of the existing system is aging, and over a 10-year period across the U.S., 19% of transit vehicles and 6% of tracks and tunnels were rated in “poor” condition. The current backlog of \$176 billion is expected to grow to more than \$270 billion through 2029. Meanwhile, transit ridership is declining.



**STATUS**

## Waste Water Treatment

The nation’s ~16,000 wastewater treatment plants are functioning, on average, at 81% of their design capacities, while 15% have reached or exceeded it. Growing urban environments will force these facilities to increasingly accommodate a larger portion of the nation’s wastewater demand. As many treatment plants and collection networks approach the end of their life spans, estimates for operation and maintenance will exceed the \$3 billion spent in 2019.



# U.S. Infrastructure Status Globally

STATUS

The United States now ranks 25<sup>th</sup> in the world for infrastructure quality, down from 5<sup>th</sup> in 2002 [10]

Question: How would you assess general infrastructure (e.g., transport, telephony, energy) in your country?

1		Switzerland	11		Portugal	21		Barbados
2		Singapore	12		Luxembourg	22		South Korea
3		Finland	13		Denmark	23		Saudi Arabia
4		Hong Kong SAR	14		Bahrain	24		United Kingdom
5		France	15		Canada	25		United States
6		UAE	16		Japan	26		Qatar
7		Iceland	17		Belgium	27		Taiwan, China
8		Austria	18		Spain	28		Czech Republic
9		Germany	19		Sweden	29		Malaysia
10		Netherlands	20		Oman	30		Slovenia

SOURCE: World Economic Forum Global Competitiveness Report, 2012-2013

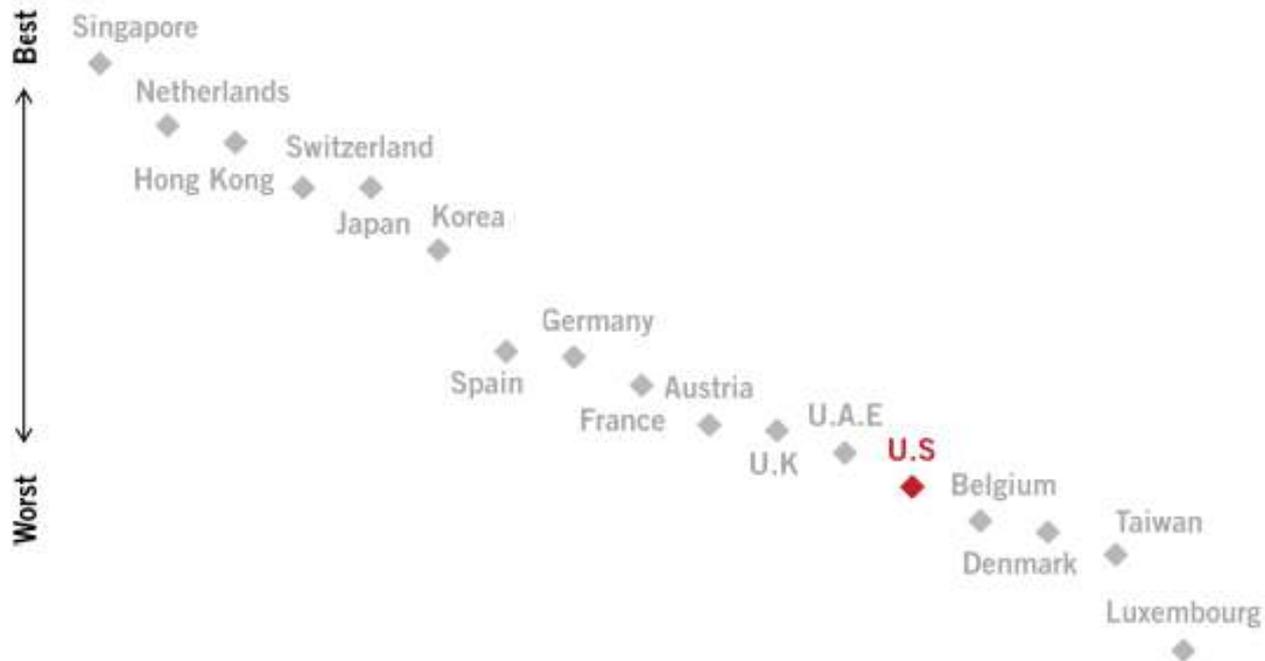
McKinsey & Company | 22

# U.S. Infrastructure Status Globally



The United States ranks 13<sup>th</sup> in quality of overall infrastructure according to the World Economic Forum [14]

## QUALITY OF OVERALL INFRASTRUCTURE



SOURCE: World Economic Forum, *The Global Competitiveness Report 2019*, October, 2019.

NOTE: The World Economic Forum score on overall infrastructure includes transport, utility, and water. Only the top 20 ranked countries are shown.

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# Common Metrics Used to Evaluate Infrastructure

- 1) **Risk of physical harm**  
e.g., bridge collapse
- 2) **Level of inconvenience**  
e.g., power outages
- 3) **Loss of jobs and income**  
e.g., park closures
- 4) **Impediment to personal development**  
e.g., lack of access to web
- 5) **Impediment to economic development**  
e.g., port system inefficiency
- 6) **Impact on the environment**  
e.g., waste treatment (human, industrial)



# Differing Metrics Lead to Debate

**Question:** *Are infrastructure components inter-dependent and impossible to address independently? For example, failure to address transit revenue shortfalls will decrease ridership, resulting in increased congestion, hampered economy, and worsened air quality.*

**Answer #1:** Overlap across metrics means all metrics should carry equal weight in making decisions regarding policies and spending.

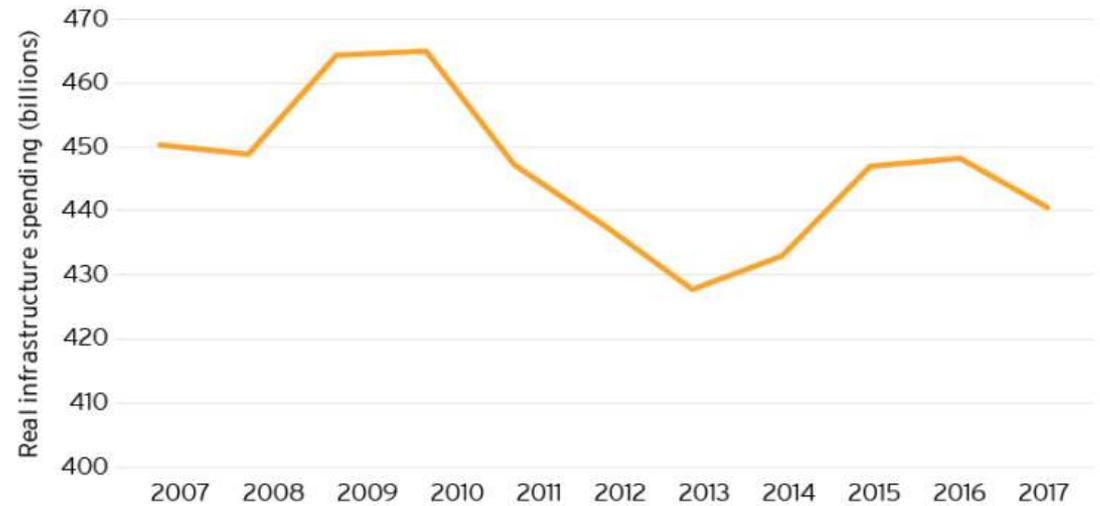
**Answer #2:** There is a clear distinction between items that pose threats to our health and safety (e.g., bridges, drinking water) and those that impact our convenience (e.g., waiting times in traffic and in airports).

**Answer #3:** Most, if not all, of our infrastructure problems cannot be solved by simply constructing more of the same. We must encourage and develop new methods, materials, approaches, and attitudes.

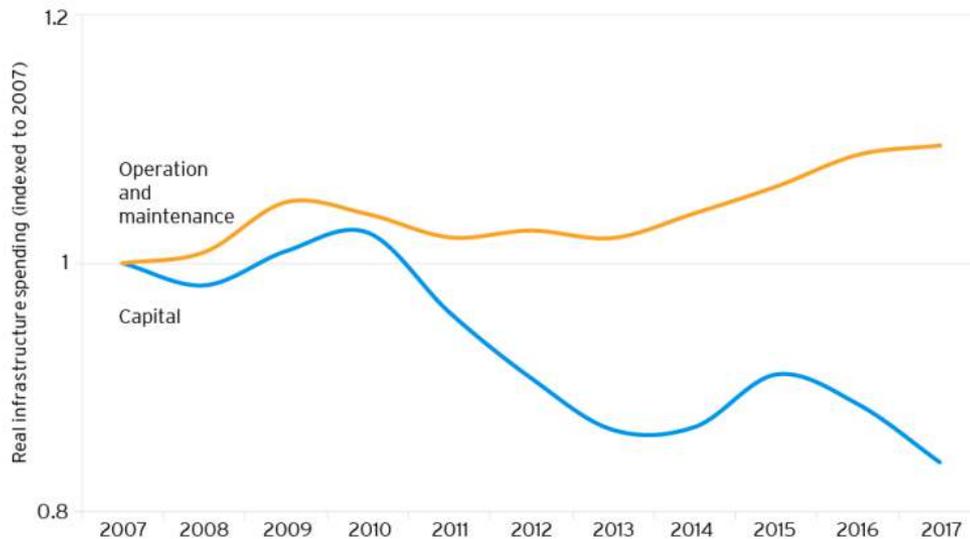
# Domestic Spending on Infrastructure

Trends in infrastructure Spending in the US [7]

United States public infrastructure spending (in billions of 2017 dollars) 2007 to 2017

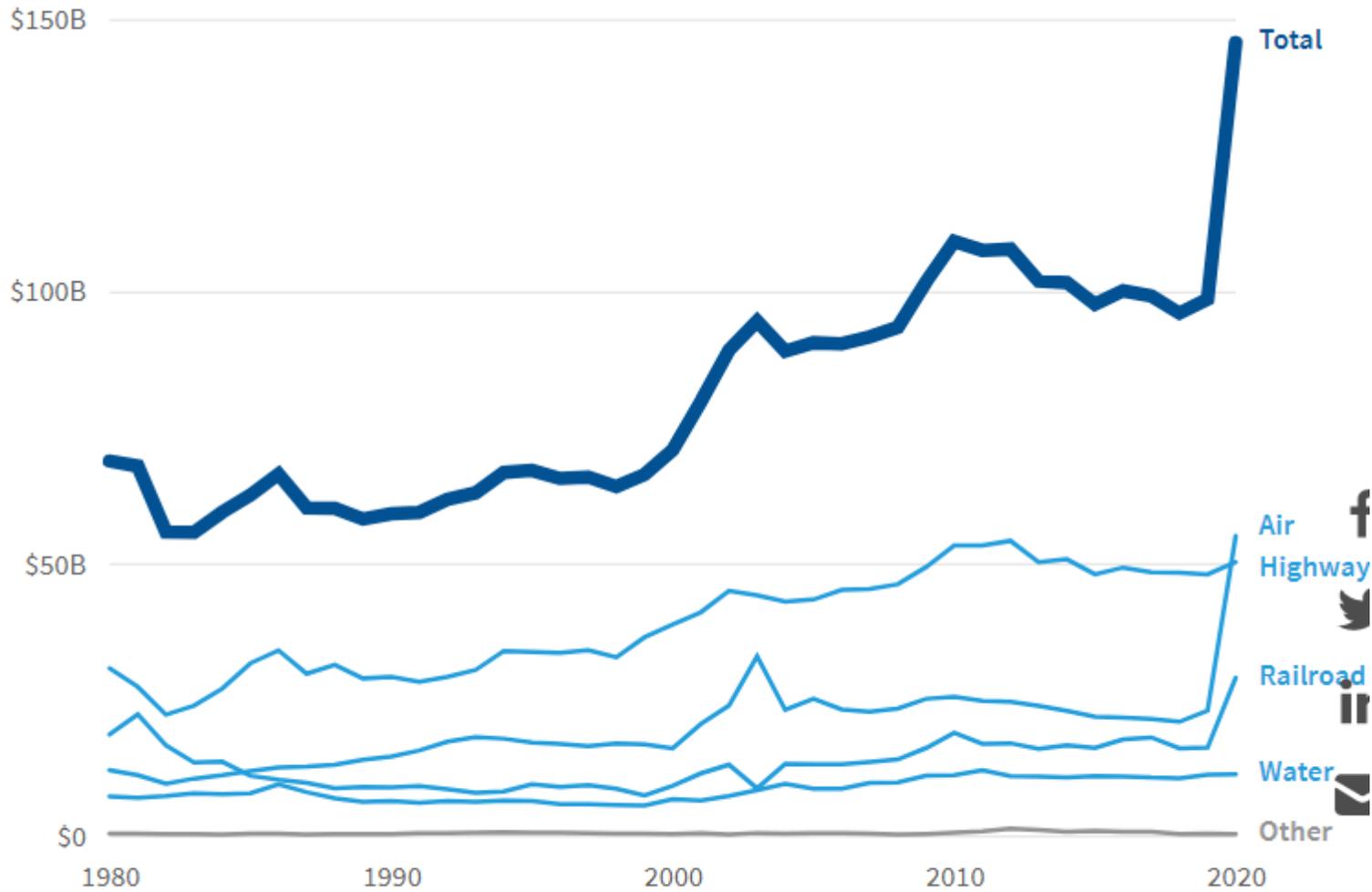


Indexed change in United States public infrastructure spending By category of spending, 2007 to 2017



# Domestic Spending on Infrastructure

Trends in infrastructure Spending in the US [8]



FEDERAL INFRASTRUCTURE SPENDING  
Adjusted for inflation

# Domestic Spending on Infrastructure

## Sources of funds ?

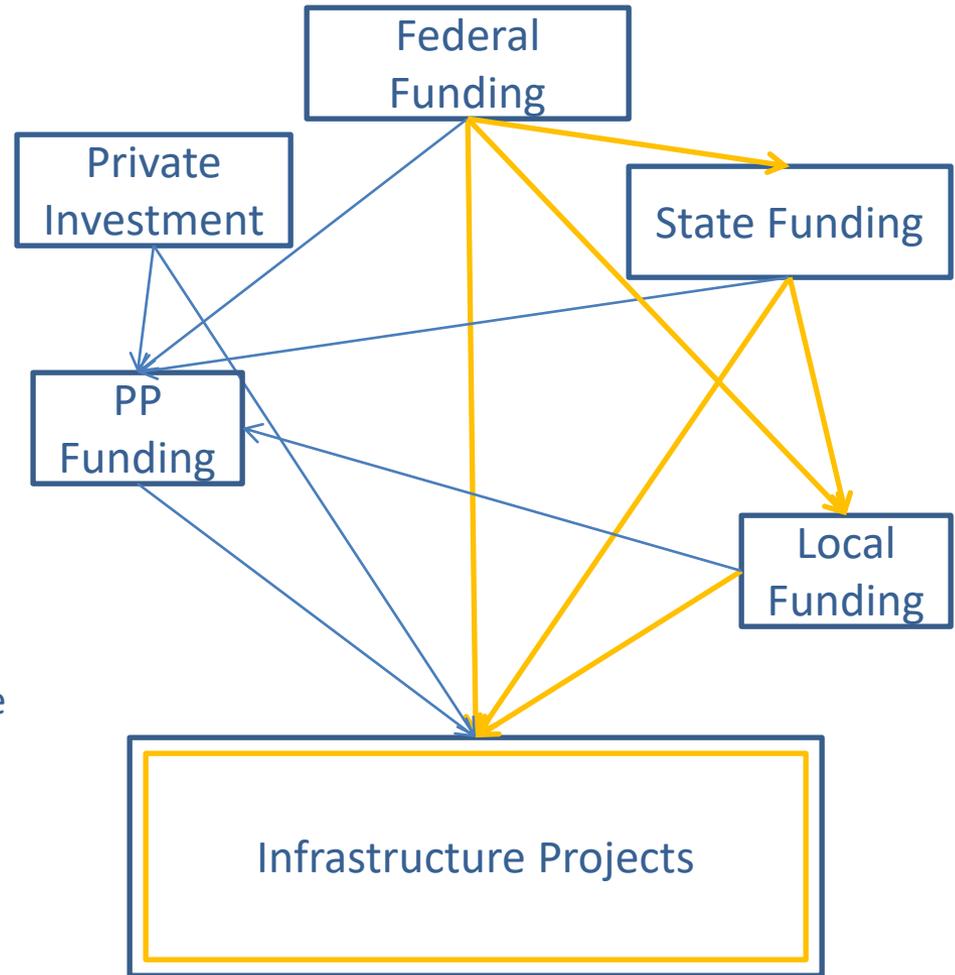
State and local governments spent \$169 billion on projects in 2018, excluding federal transfers.

In 2018, the federal gov't spent \$30B directly on infrastructure and granted an additional \$70B in infrastructure funding to states.

## How are funds awarded?

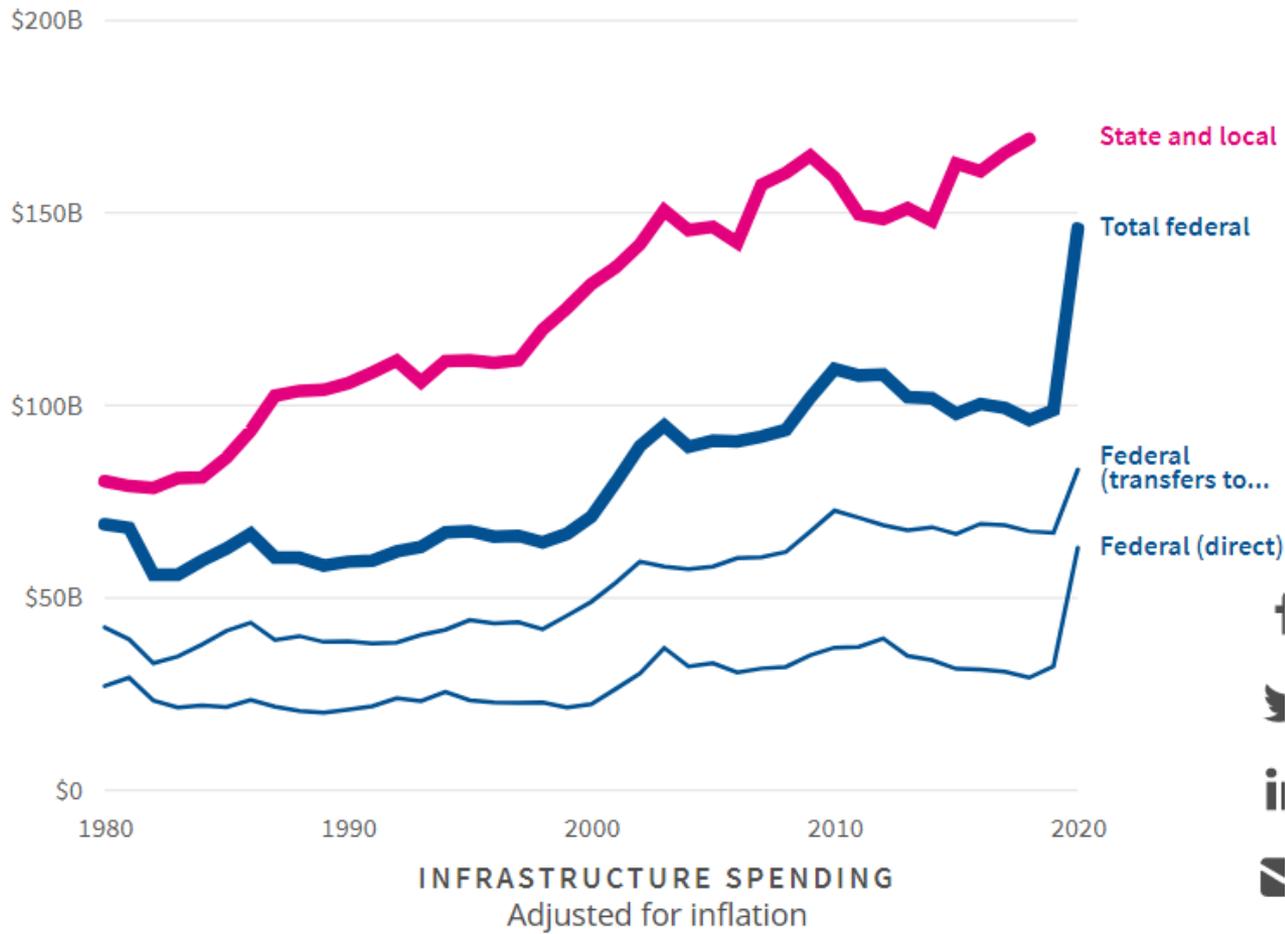
Example #1: In 2020 the USDOT issued \$906M via its Infrastructure for Rebuilding America or INFRA discretionary grant program with funds funneled largely through state DOT's. Congress Reviewed all awards. 53% of grants were awarded to rural projects, and six awards made to projects located in an Opportunity Zone.

Example #2: A \$700 million bond sale that will aid the NCDOT was approved in October 2020. They are part of the \$3 billion "Build NC" transportation bond package (Senate Bill 758). Repayment of the Build NC Bonds will come from the Highway Trust Fund, which has three primary revenue sources: highway use tax, motor fuel excise tax, & title/registration fees.



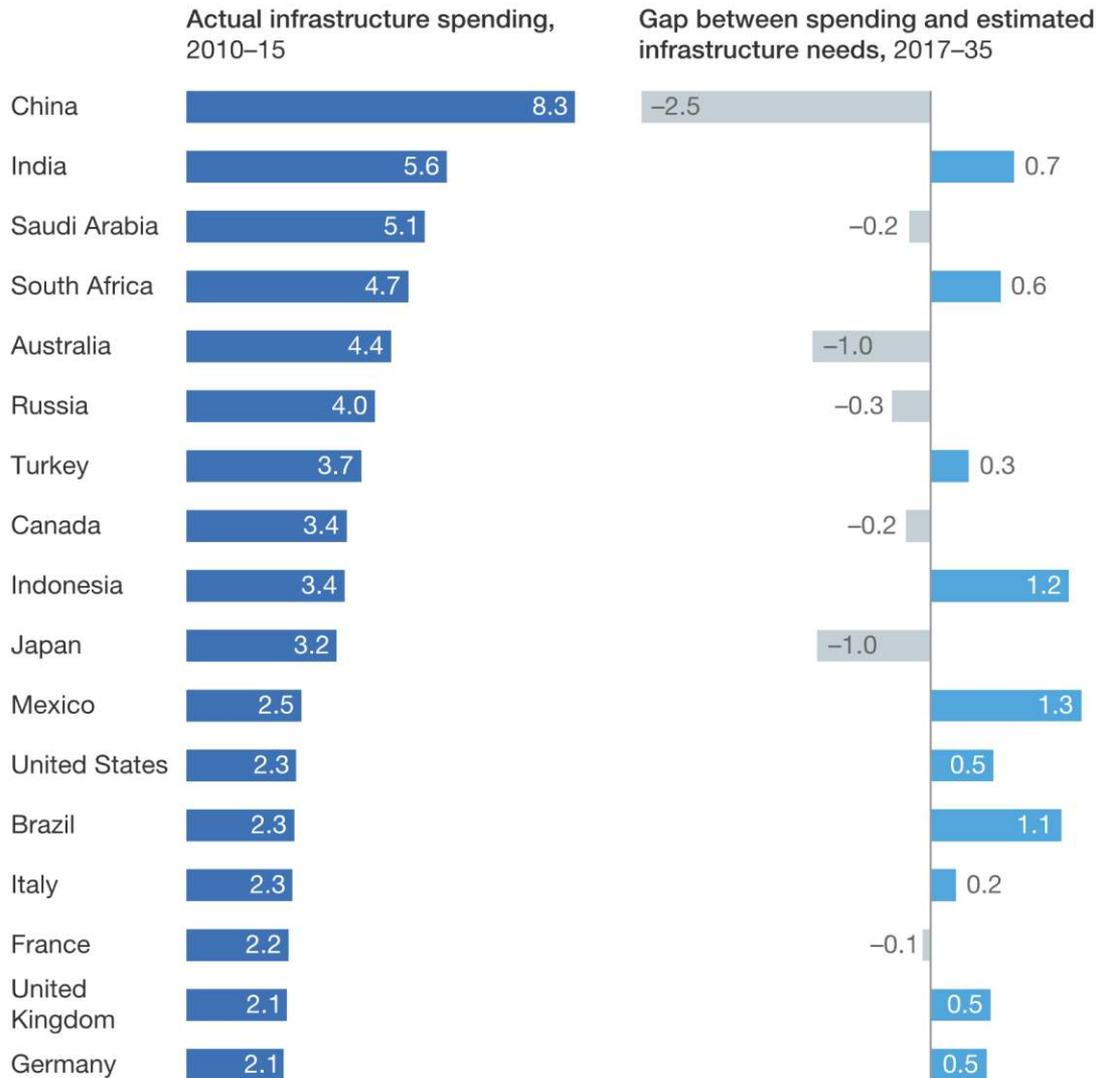
# Domestic Spending on Infrastructure

Trends in infrastructure Spending in the US [8]



# Global Spending on Infrastructure

Economic infrastructure, % of GDP



# Establishing Infrastructure Policy and Priorities

## 1) Conferences, panels, symposia, conferences, think tanks, .....

In January 2021, the World Economic Forum (WEC) [15] predicted the power and prestige of the Davos Agenda (January 25-29, 2021) could lead to needed reform in global infrastructure policy. The WEC described four steps to build a sustainable world through infrastructure.

### **1) Embrace technology**

The infrastructure sector lags others in adopting emerging technologies.

### **2) Focus on sustainability**

Both the EU and Chinese plans focus on green infrastructure to varying degrees.

### **3) Seek equity and justice through social outcomes**

At its core, infrastructure connects people and creates opportunities within communities; thus, it is a direct reflection of the values of a society.

### **4) Expand Environmental, Social, Governance (ESG) financing**

Newly established national infrastructure banks in Canada and the UK will assist governments in attracting private financing to public projects.

# Establishing Infrastructure Policy

## Federal initiatives

- 1) Legislation driven by the President: For example, President Biden's current \$2T- \$3T proposed infrastructure bill:
  - a) repair roads, bridges, waterways and rails;
  - b) retrofit buildings, improve safety;
  - c) upgrade schools/education infrastructure;
  - d) build green transit, increase use of electric vehicles, support climate-related R&D;
  - e) provide more housing



- 2) Legislation driven by Congress

46 bills have been proposed in Congress in 2021 [17]:

- a) proposed by 26 states (MA (6), NY (5), CA (4), NC (3), TX (3))
- b) 31 proposals from the House and 15 from the Senate
- c) 30 proposals by Democrats and 16 proposals by Republicans
- d) average predicted rate of passage = ~5%
- e) topics cover schools, bridges, parks, sanctuary cities, international relationships,.....



- 3) Groundwork for policies/legislation through national labs and other funding sources (e.g., NSF)

- a) funding for R&D, prototypes, preliminary applications for new programs and technologies
- b) developments can lead to legislation to guarantee broader applications



# Establishing Infrastructure Policy

## NC initiatives

### Legislation driven by the Governor:

- a) Growing Rural Economies with Access to Technology (GREAT) Grant Program (2020) and will distribute funds through the N.C. Department of Information Technology (NCDIT) for expanding internet connectivity
- b) The North Carolina Rural Infrastructure Authority (RIA) approved 17 grants (2019) to improve local water and sewer systems.
- c) Build NC Bond Act (2018) will expedite highway-improvement



### Legislation driven by the General Assembly

40 bills have been proposed in the Assembly in 2021 [19]. Topics cover schools, broadband, social equity, buildings, education, airports, transit, .....

### Groundwork for policies/legislation

- a) through funding from State grants [18];e.g., State Rural Grants, Utility Accounts, Rail Industrial Access Program, etc.
- b) through funding from State agencies, including NCDOT, WRII, UNCROI, .....

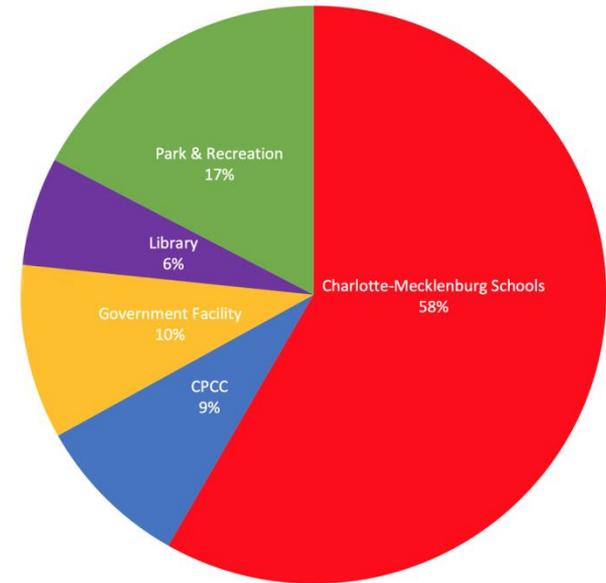


# Establishing Infrastructure Policy

## Charlotte-Mecklenburg initiatives

County-wide Capital Improvement Program (CIP) [19]: Mecklenburg County faces and increasing demand for schools, parks and public services. The County will invest ~\$1.75 billion to fund these improvements through a 5-year (2019-2023) CIP. Funding for these projects comes from three basic sources: borrowing through general obligation bonds (53%), other funding (42%), and direct financing (5%).

Funding Allocation by Category



## City wide Capital Investment Plan (CIP) [20]:

Begun in 2014, Charlotte's CIP is a long-range infrastructure investment program focuses on transportation, housing, neighborhood improvement, and economic development. Over 30 major projects were funded (\$81(+)M) through 2020 from bonds supported by a 3.17¢ property tax increase. A new bond package for \$197(+)M was approved by voters in November 2020 for projects for 2021-2025. For example, the "North Bridge over I-85" project (\$38.1M) will connect University Research Park with University Place and UNC Charlotte. Grading is expected to begin in August 2021.



# Global Best Practices

With 7 times the population density of New York, **Hong Kong** is spending ~\$13B on its infrastructure aimed at improving housing, rail, healthcare, mass transit, and urban land use. The aim is to modernize and streamline the planning, construction, and management processes through digitization, with >\$200M planned for workforce training.



•**Singapore** will spend >\$95B on its infrastructure with the aim of reducing highway traffic. With one of the world's largest refining and petrochemical complexes, Singapore is investigating non-fossil fuel options for its power and transportation systems. Plans include phasing out internal combustion engines by 2040, manufacturing electric vehicles, and importing electricity from Southeast Asia.

# Global Best Practices

At a cost of ~\$6.3B, a new automated light rail network through Montréal, Canada will be served by fully electric, driverless trains. It will be the fourth-longest automated transportation system in the world and one of the most innovative rail projects ever.



Reducing the number of cars on roads and highways translates into energy savings, reduced demand for oil, time efficiency, and fewer greenhouse emissions. With these focus areas, France has led the use of high-speed rail (HSR) throughout Europe. Expanding its current ~\$2,000 miles of HSR, France anchors a European HSR network of ~7,000 miles. (In comparison, the U.S. has ~54 miles of HSR).

# Domestic Best Practices

By 2030, railway company Norfolk Southern will upgrade the Crescent Corridor, a freight rail network that runs through 13 states and connects **New Orleans to New Jersey**. The ~\$2.5 billion expansion will move more goods using rail, instead trucks which are more expensive and produce more pollution. The public will benefit from cleaner air and reduced highway congestion. The USDOT chipped in more than \$136M with the rest of the funds coming from states and Norfolk Southern.

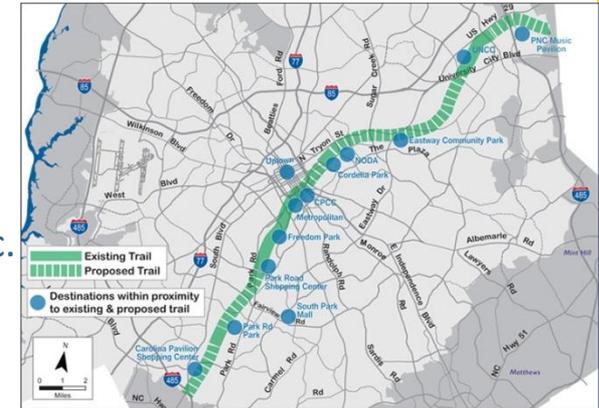


The Brent Spence Bridge, connecting **Ohio and Kentucky** over the Ohio River, is on one of the busiest trucking routes in the U.S., with freight equaling 3% of the nation's gross domestic product (GDP) crossing the bridge each year. The bridge carries both I-75 and I-71 traffic and connects 10 States, yet it is rated as functionally obsolete by the National Bridge Inventory and generally considered an example of the nation's worst infrastructure. Current repairs focus on high performance materials for coating and patching and advanced signalization for improved access and egress.



# Charlotte Area Best Practices

The City of Charlotte and Mecklenburg County have partnered to create an ~30 mile trail stretching from the City of Pineville through Center City to UNC Charlotte and the Cabarrus County line. The Cross Charlotte Trail will allow residents to travel from one end of Charlotte to the other, allowing more pedestrian and bicycle traffic.



Construction is underway on the Charlotte Gateway Station project, the future multi-modal station that will consolidate public transit and intercity transportation modes. This NCDOT project is funded for \$86M. It will reduce automobile traffic and improve travel efficiency.

Planning and design is underway for the LYNX Silver Line, 26-mile light rail project from the City of Belmont in Gaston County, through Center City Charlotte and the Town of Matthews, with a potential extension into Union County. Goals are to reduce traffic congestion, support economic development, and improve travel efficiency.



# Rethinking our Infrastructure Process

## Suggestions for Fixing U.S. Infrastructure [11]

### 1) Revamp the Highway Trust Fund

The nation's highways are primarily financed by the Highway Trust Fund, which gets most of its money from a gas tax of 18.4 cents per gallon, unchanged since 1993. More hybrid and electric vehicles guarantee a future that is perpetually underfunded.



### 2) Get Washington to Take the Issue Seriously

On a few key federal committees, infrastructure is a major issue. But for most, it's not front burner; it's confusing and invisible to many voters, and, therefore, not important to many lawmakers.



### 3) Empower State and Local Governments

States pay the majority of infrastructure costs. The Fed portion needs to grow in terms of amount and flexibility. Suggestions include reducing the confusing number of federal programs, creating an infrastructure bank, expanding public-private partnerships, and allowing more tolling on interstate highways.



# Rethinking our Infrastructure Process

## Suggestions for Fixing U.S. Infrastructure (Continued)

### 4) Increase Rural Access

Transportation planning often focuses on urban development, and rural highways are neglected, leading to stretched capacity, reduced connectivity, and strained two-lane roads used by heavy trucks. Mass transit in rural areas is even more problematic.



### 5) Get Cities to Think Big

Revenue shortfalls and increasing expenses force many cities to focus on repairing what they have. However, a repair mentality alone will not keep up with growth. Some cities have decided to go big with multi-billion dollar projects to expand and modernize infrastructure.



### 6) Make Bridges Smarter

Traditional assessment methods for monitoring a bridge's health, such as visual inspection, do not catch all structural problems. New non-destructive and sensor/diagnostic technologies constantly monitor bridges, alerting officials to structural problems before it's too late.



# Strengthening the Infrastructure Improvement Process

1) Direct a higher % of funds directly to improvements. As one example, in 2018 spending (\$23.1B) by the USDOT, eight of the top 10 expense categories (\$20.8B) were for “support” services and only 10% went to “shovels in the dirt” categories [4].

## Top 10 Categories Funded Through Contracts, by Category

Communications equipment manufacturing (other)	\$4.5B
Engineering services	\$3.3B
Air transportation support activities	\$2.2B
Search, detection, navigation, guidance, aeronautical, and nautical navigation and instrument manufacturing	\$1.8B
Highway, street, and bridge construction	\$1.7B
Administrative and general management consulting services	\$1.0B
Professional and management development training	\$800M
All other professional, scientific, and technical services	\$800M
Deep-sea freight transportation	\$600M
Other computer-related services	\$600M

# Strengthening the Infrastructure Improvement Process

2) Direct a higher % of funds based on use, demand, and need, rather than on politics. As one example, of the top 10 states receiving funding in 2018, Virginia received more than the next two states combined for road, bridge, and railway construction [4].

## States and Territories Receiving the Most Contract Money



# Strengthening the Infrastructure Improvement Process

3) Repair the U.S. innovation infrastructure. Excerpts from an article by Deborah Wince-Smith [4]:

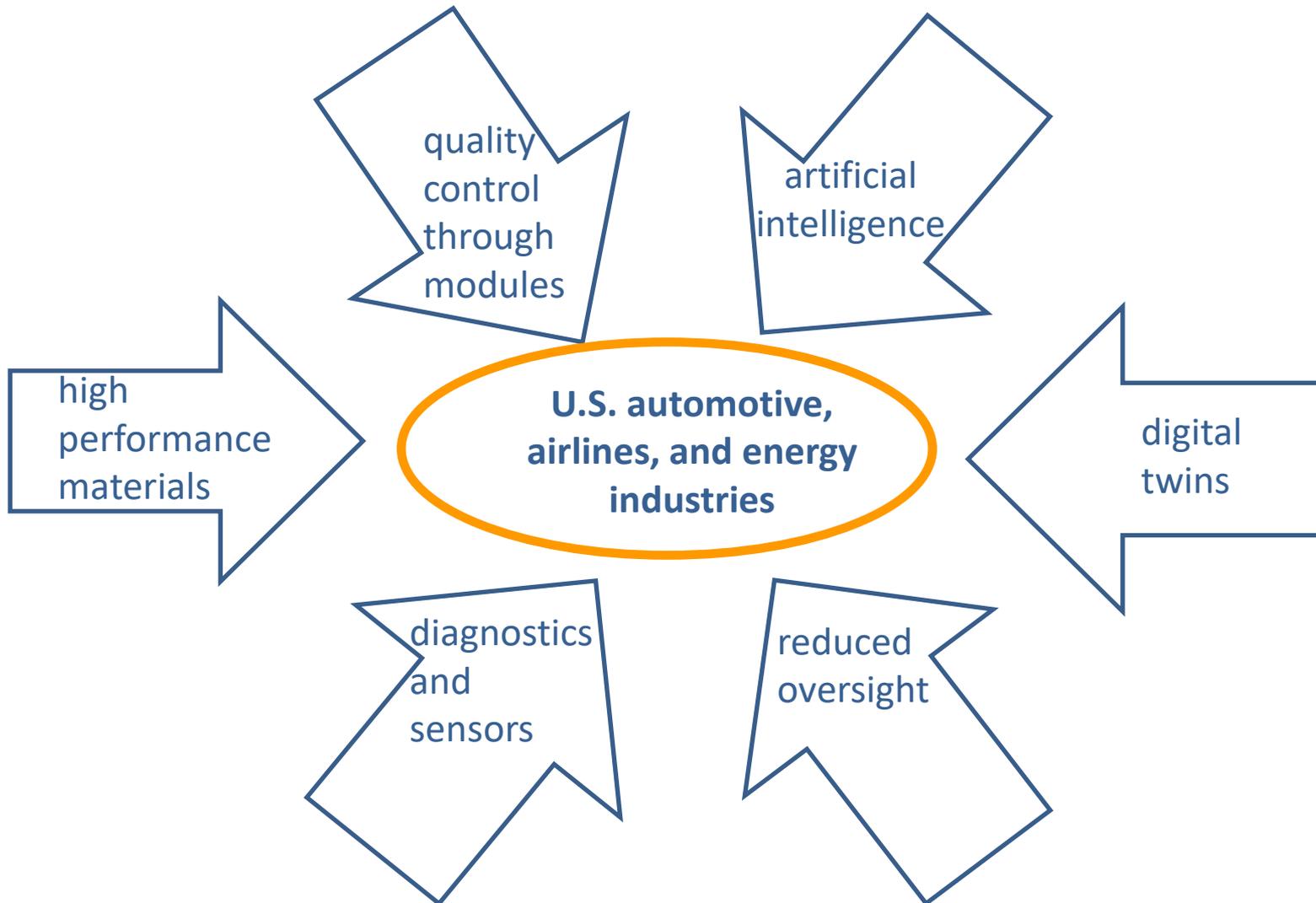
- a) The US has capacity and resources to respond effectively to these challenges, yet we end up scrambling to adapt (e.g., COVID 19). Our economic prosperity can no longer afford complacency.
- b) Some of our counterparts abroad are investing in their national infrastructure at unprecedented levels with the specific aim of toppling the United States as a global and innovation leader.
- c) The infrastructure that supports our world-class universities and the National Laboratories is as critical to ground-breaking work and economic growth as traditional infrastructure, yet at a much lower cost.
- d) Critical U.S. innovation infrastructure is eroding. For example, ~50% of the facilities at the 17 laboratories of the USDOE National Laboratory system are rated as inadequate to meet their mission.

# Strengthening the Infrastructure Improvement Process

- 4) Engage in public-private partnerships [9]
  - a) spread the cost of infrastructure over the lifetime of an asset
  - b) assemble funds more quickly to start construction
  - c) provide benefits in terms of cost efficiencies and innovation
  - d) establish efficient risk-management
  - e) build-in accountability; that is, making payment contingent on performance tends to reduce cost overruns and schedule delays.
  - f) encourage quality through multi-year contracts b/c the private sector is responsible for well-defined maintenance obligations many years down the road. The same cannot be said for most purely public-funded projects.

# Strengthening the Infrastructure Improvement Process

5) Create a willingness to engage new means and methods



# References

## Photos

Slide #2

[www.queens.edu](http://www.queens.edu)

Slides #4- #8

[www.gettyimages.com](http://www.gettyimages.com)

## Articles

- [1] “2021 Report Card on America’s Infrastructure,” American Society of Civil Engineers (ASCE), [www.infrastructurereportcard.org](http://www.infrastructurereportcard.org)
- [2] “Does America Really Have an Infrastructure Crisis?” The Week, <https://www.msn.com/en-us/news/opinion>, March 31,2021.
- [3] Turner, M. A., “Local Transportation Policy and Economic Opportunity,” The Hamilton Project of the Brookings Institution, <https://www.brookings.edu/research>, January 2019, pp.1-23.
- [4] “Top Infrastructure Spending by City and State,” <https://www.zoro.com/resourcehub/us-infrastructure-spending-by-city-and-state>, February 2019.
- [5] Wince-Smith, D., “Fixing the Crumbling US Innovation Infrastructure,” [www.forbes.com](http://www.forbes.com), March 29,2021.
- [6] George, A., Kaldany, R.R., and Losavio,J., “The world is facing a \$15 trillion infrastructure gap by 2040. Here's how to bridge it,” [www.weforum.org](http://www.weforum.org), World Economic Forum, April 11, 2019.
- [7] Kane, J. and Tomer A., “Shifting into an era of repair: US infrastructure spending trends,” Metropolitan Infrastructure Initiative, <https://www.brookings.edu/research>, Brookings Institution, May 10, 2019.
- [8] “What does America spend on transportation and infrastructure?” USA Facts, State of the Union, <https://usafacts.org/state-of-the-union>, March 12, 2021.
- [9] Gaiger, S. and Barend, S., “Private Financing of Infrastructure: Serving the Public Interest as Well as Profits,” The Future of Infrastructure, AECOM, <https://infrastructure.aecom.com>, 2021.
- [10] Kawa, L., “America's Infrastructure Ranks 25th In The World,” Business Insider, <https://www.businessinsider.com>, January 6, 2013.
- [11] Cournoyer, C., “Six Ideas for Fixing the Nation's Infrastructure Problems”, Governing – the Future of States and Localities, <https://www.governing.com/archive>, June 2011 .

# References (Continued)

## Articles

- [12] McBride, J. and Moss, J., “The State of U.S. Infrastructure”, Council on Foreign Relations Backgrounder, <https://www.cfr.org/backgrounder>, September 1, 2020.
- [13] “U.S. Chamber Calls for Productive Solutions from Democrats and Republicans to Enact Infrastructure Legislation”, <https://www.uschamber.com/press-release>, March 31, 2021 .
- [14] “U.S. Ranks 13<sup>th</sup> in Infrastructure Quality”, Peter G. Peterson Fdn., <https://www.pgpf.org/chart-archive>, November 12, 2019.
- [15] Losavio, J. and Tsai, O., “4 big infrastructure trends to build a sustainable world,” World Economic Forum, <https://www.weforum.org/agenda>, January 18, 2021.
- [16] Stein, J. and Pager, T., “White House prepares massive infrastructure bill.... “, The Washington Post, March 22, 2021.
- [17] “Infrastructure development,” govtrack, <https://www.govtrack.us/congress/bills>, April 2,2021
- [18] “Public Infrastructure Funds,” NC Dept. of Commerce, <https://www.nccommerce.com/grants-incentives> April 2, 2021.
- [19] North Carolina General Assembly, <https://www.ncleg.gov/Search/BillText>, April 2,2021
- [20] “Capital Improvement Program,” Mecklenburg County, <https://www.mecknc.gov/CountyManagersOffice/OMB/Documents>
- [21] “Charlotte Future, Capital Investment Plan”, City of Charlotte, <https://charlottenc.gov/charlottefuture/CIP>