Bumpy Roads Ahead

America's Roughest Rides and Strategies to make our Roads Smoother

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- Nearly one-third (32 percent) of the nation's major urban roads – Interstates, freeways and other arterial routes – have pavements that are in substandard condition and provide an unacceptably rough ride to motorists

- An additional 39 percent of the nation’s major urban roads and highways have pavements that are in

- The 25 urban regions

- The following chart shows the 25 urban regions with at least 500,000 people

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With vehicle travel growth returning to pre-recession rates and large truck travel anticipated to grow significantly, the result will be an increase in traffic and wear and tear on the nation's urban roads and highways. The additional travel will increase the amount of road, highway and bridge investment needed to improve conditions and to meet the nation's transportation needs.

- Vehicle travel in the U.S. increased by 15 percent from 2000 to 2015. U.S. vehicle travel during the first eight months of 2016 increased 3.1 percent from the same period in 2015.

- Travel by large commercial trucks in the U.S. increased by 26 percent from 2000 to 2014. Large trucks place significant stress on our roads and highways.

- The level of heavy truck travel nationally is anticipated to increase by approximately 72 percent from 2015 to 2030, putting greater stress on the nation's roadways.

- The 2015 AASHTO Transportation Bottom Line Report found that the U.S. currently has a $740 billion backlog in improvements needed to restore the nation's roads, highways and bridges to the level of condition and performance needed to meet the nation's transportation demands.

- The 2015 AASHTO Transportation Bottom Line Report found that the nation's road, highway and bridge backlog included $392 billion in needed road and highway repairs to return them to a state of good repair; $112 billion needed in bridge rehabilitation and $237 billion in needed highway capacity expansions to relieve traffic congestion and support economic development.

The federal government is a critical source of funding for road and highway repairs. The current five-year federal surface transportation program includes modest funding increases and provides states with greater funding certainty, but falls far short of providing the level of funding needed to meet the nation's highway and transit needs. The bill does not inc4(a)1(7og)5(i)-2plrorThe cuOl]TJ -8.provty, byfre(ain)]5es stJ 0.

- In addition to federal motor fuel tax revenues, the FAST Act will also be funded by $70 billion in U.S. general funds, which will rely on offsets from several unrelated federal programs including the Strategic Petroleum Reserve, the Federal Reserve and U.S. Customs.

- According to the 2015 AASHTO Transportation Bottom Line Report, a significant boost in investment in the nation's roads, highways, bridges and public transit systems is needed to improve their condition and to meet the nation's transportation needs.

- AASHTO's report found that based on an annual one percent increase in VMT annual investment in the nation's roads, highways and bridges needs to increase 36 percent, from $88 billion to $120 billion, to improve conditions and meet the nation's mobility needs, based on an annual one percent rate of vehicle travel growth. Investment in the nation's public transit system needs to increase from $17 billion to $43 billion.

- The Bottom Line Report found that if the national rate of vehicle travel increased by 1.4 percent per year, the needed annual investment in the nation's roads, highways and bridges would need to increase by 64 percent to $144 billion. If vehicle travel grows by 1.6 percent annually the needed annual investment in the nation's roads, highways and bridges would need to increase by 77 percent to $156 billion.

Projects to improve the condition of the nation's roads and bridges could boost the nation's economic growth by providing significant short- and long-term economic benefits.

- Highway rehabilitation and preservation projects provide significant economic benefits by improving travel speeds, capacity and safety, and by reducing operating costs for people and businesses. Roadway repairs also extend the service life of a road, highway or bridge, which saves money by postponing the need for more expensive future repairs.

- The Federal Highway Administration estimates that each dollar spent on road, highway and bridge improvements results in an average benefit of $5.20 in the form of reduced vehicle maintenance costs, reduced delays, reduced fuel consumption, improved safety, reduced road and bridge maintenance costs, and reduced emissions as a result of improved traffic flow.

- Resurface roads in a timely fashion using pavement materials designed to be the most durable given local climate and the level and mix of traffic on the road.

Introduction

Vehicle Travel Trends

Increases in vehicle travel since 2000 have resulted in a significant increase in wear and tear on the nation's roads. Vehicle travel growth, which slowed significantly as

and other principal arterials is collected for all system mileage, whereas pavement data for minor arterial and all collector roads and highways is based on sampling portions of roadways as prescribed by FHWA to insure the data collected is adequate to provide an accurate assessment of pavement conditions on these roads and highways.

The "ride quality" of highways and roadways is typically evaluated using the International Roughness Index (IRI), although some roads were also rated by the Present Serviceability Rating (PSR). While there may be some variance in how transportation officials apply these indices, the FHWA data are the only national source of pavement condition ratings based on a consistent criteria.

Using this information, TRIP categorizes the condition of a region's roads and highways into poor, mediocre, fair or good condition. The FHWA has found that a road surface with an IRI rating below 95 provides a good ride quality, a road with an IRI from 95 to 170 provides an acceptable ride quality, and a road with an IRI above 170 provides an unacceptable ride quality.[5] Based on the PSR scale, road surfaces rated 3.5 or higher are in good condition, a rating of 3.1 to 3.4 indicates a road is in fair condition, roads between 2.6 to 3.0 are rated in mediocre condition, and roadways that receive a PSR rating of 2.5 or less are in poor condition. The FHWA finding is based on a study that measured driver reactions to various road conditions to determine what level of road roughness was unacceptable to most drivers.[6] The scale used to rate

Chart 1. Pavement conditions based on IRI or PSR rating.

	IRI	PSR
Substandard (Poor)	Above 170	2.5 or less
Mediocre	120-170	2.6 – 3.0
Fair	95-119	3.1 – 3.4

Roads rated as being in either mediocre or fair condition may also show more

Chart 2. Urban areas* (population 500,000 or more) with highest share of major roads and highways with pavements providing an unacceptable ride quality

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The Cost to Motorists of Deteriorated Roads

When road surfaces deteriorate, motorists are taxed in the form of additional

TRIP estimates that driving on roads in need of repair costs the average driver $523 annually in extra vehicle operating costs. $112 billion nationwide. Individual driver operating costs may be somewhat higher or lower depending on the amount of travel by an individual driver and the type of vehicle driven, as larger vehicles tend to have greater increases in operating costs due to substandard roads.

In urban areas with a population of 500,000 or greater, Oklahoma City drivers incur the greatest annual extra vehicle operating costs due to driving on rough roads. The other nine urban regions with at least 500,000 in population where drivers pay the most (in order of rank) because of rough roads are: Tulsa, San Francisco-Oakland, Los Angeles-Long Beach-Santa Ana, Detroit, San Jose, Milwaukee, Omaha, Bridgeport-Stamford and San Antonio.

Chart 4. Urban areas* (population of 500,000 or more) with highest annual additional vehicle operating cost per motorists as result of driving on roads with unacceptable ride quality.

	500K+ URBAN AREA	STATE	VOC
1	Oklahoma City	OK	$ 1,025
2	Tulsa	OK	$ 998
3	San Francisco--Oakland	CA	$ 978
4	Los Angeles--Long Beach--Santa Ana	CA	$ 892
5	Detroit	MI	$ 865
6	San Jose	CA	$ 863
7	Milwaukee	WI	$ 861
8	Omaha	NE-IA	$ 852
9	Bridgeport--Stamford	CT	$ 797
10	San Antonio	TX	$ 791
11	Denver--Aurora	CO	$ 753
12	Cleveland	OH	$ 748
13	Honolulu	HI	$ 745
14	Grand Rapids	MI	$ 742
15	New Haven	CT	$ 728
16	Chicago	IL-IN	$ 727
17	San Diego	CA	$ 722
18	Baltimore	MD	$ 708
19	Albuquerque	NM	$ 703
20	Salt Lake City	UT	$ 698
21	Seattle	WA	$ 695
22	Akron	OH	$ 690
23	Boston	MA-NH	$ 680
24	New York--Newark	NY-NJ	$ 666
25	Springfield	MA-CT	$ 665

* An urban area includes the major city in a region and its neighboring or surrounding suburban areas

Source: TRIP analysis based on Federal Highway Administration data

In urban areas with a population between 200,000 and 500,000, Concord drivers incur the greatest annual extra vehicle operating costs due to driving on rough roads. The other nine mid-sized urban regions with a population between 200,000 and 500,000, where drivers pay the most (in order of rank) because of rough roads are Madison, Antioch, Jackson, Victorville-Hesperia-Apple Valley, Flint, Colorado Springs, Canton, Peoria and Fort Wayne.

Chart 5. Urban areas* (population between 200,000 and 500,000) with highest annual additional vehicle operating cost per motorists as result of driving on roads with unacceptable ride quality

	200-500K URBAN AREA	STATE	VOC
1	Concord	CA	$ 1,014
2	Madison	WI	$ 974
3	Antioch	CA	$ 883
4	Jackson	MS	$ 862
5	Victorville--Hesperia--Apple Valley	CA	$ 854
6	Flint	MI	$ 825
7	Colorado Springs	CO	$ 776
8	Canton	OH	$ 770
9	Peoria	IL	$ 738
10	Fort Wayne	IN	$ 734
11	Savannah	GA	$ 729
12	Stockton	CA	$ 711
13	Des Moines	IA	$ 705
14	Baton Rouge	LA	$ 698
15	Davenport	IA-IL	$ 696
16	Santa Rosa	CA	$ 663
17	Shreveport	LA	$ 661
18	Scranton	PA	$ 650
19	Provo--Orem	UT	$ 646
20	Reading	PA	$ 641
21	South Bend	IN-MI	$ 637
22	Thousand Oaks	CA	$ 629
23	Trenton	NJ	$ 629
24	Huntsville	AL	$ 619
25	Lubbock	TX	$ 613

* An urban area includes the major city in a region and its neighboring or surrounding suburban areas

Source: TRIP analysis based on Federal Highway Administration data

A listing of additional vehicle operating costs due to driving on roads in substandard condition for urban areas with populations over 500,000 can be found in Appendix C. Additional vehicle operating costs for urban areas with a population between 200,000 and 500,000

The Lifecycle of Pavement

Paved roadway surfaces are considered to have five stages in their life cycle. Each of these stages has a significant impact on the smoothness of the road surface.[15] The first stage is the initial design of the roadway, including the road's dimensions, type of materials, thickness of base and driving surfaces, and drainage system for the road, all of which have a significant impact on the quality and performance of the pavement surface.

The second stage is the actual construction or reconstruction of the road or highway surface. The quality of the construction process has a significant impact on the longevity of the pavement surface.

The third stage is the first few years in use when a roadway surface starts to experience some initial deterioration as a result of traffic volume, rain, snow, solar radiation and temperature changes. At this stage, a road surface appears to still be in good condition and generally provides a smooth ride to motorists.

The fourth stage begins when the rate of deterioration accelerates and visible signs of distress such as potholes, cracking and other distresses, which have a negative impact on driving performance, occur. If roads are not repaired at stage four, they will fall into stage five – disintegration and systemat

Strategies for Smooth Roads

Improving the smoothness of the nation's highways and roads is a key priority for transportation agencies. Significant progress has been made over the last decade in pavement mater

which improve ride quality, correct small surface irregularities and improve surface drainage and friction. For pavement preservation strategies to be most effective, they must be applied while the pavement surface is still in good condition, before any structural damage occurs.

The timing of the maintenance and rehabilitation of road surfaces is critical, impacting the cost-effectiveness of the repairs and ultimately the overall quality of a regional road network. It is estimated that a pavement preservation program can reduce the life cycle costs of a pavement surface by about one-third over a 25-year period.[17] The preventive maintenance approach may require several applications of minor sealing or resurfacing to a pavement surface over its lifetime, but reduces costs by delaying the need for more costly reconstruction.

A 2005 book from the National Center for Pavement Preservation (NCPP), At the Crossroads: Preserving our Highway Investment, recommended that transportation agencies adopt a pavement preservation strategy for the maintenance of the nation's roads and highways.[18] Instead of a reactive approach to roadway pavement maintenance that provides repairs to the road surfaces in the worst condition, the book recommends using a proactive approach that provides initial maintenance to pavements still in good condition, to significantly delay the need for costly reconstruction.

The NCPP book noted that preventive maintenance can only be performed on road surfaces that are structurally sound. All other road and highway surfaces first need to be reconstructed before a preventive maintenance approach will be effective. The book recommends that transportation agencies implement a preventive maintenance program for roads and highways that are structurally sound and in good condition.

also suggest that transportation agencies should continue to make surface repairs to roads and highways that are not structurally sound to maintain them in reasonable condition until there is adequate funding for the reconstruction of these roads, at which point transportation agencies can then implement a preventive maintenance program for these improved roads.[19]

A report by FHWA found that an over-reliance on short-term pavement repairs will fail to provide the long-term structural integrity needed in a roadway surface to guarantee the future performance of a paved road or highway. The 2010 report *"Beyond the Short Term: Transportation Asset Management for Long-Term Sustainability, Accountability and Performance,"* warned that transportation agencies that focus only on current pavement surface conditions will eventually face (ve)-1Tighway network with an overwhelming backlog of pavement rehabilitation and replacement needs.[20]

Improved Pavement Materials

Since the late 1980s, there has been significant research into developing pavement materials and construction practices that will provide a road surface that is more durable and can better withstand various climates and traffic loads. The resulting pavements have been found to last longer, require less maintenance (ve)-nd have a lower cost over the life cycle.[21] A variety of pavement designs and materials have been developed since that can be tailored to the individual requirements of various sections of roads (ve)-nd, highways including high performance concrete pavements (ve)-nd improved hot-mix asphalt pavements. Some pavement designs now call for varying material compositions

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site for repair by removing loose material and underlying moisture, the subsequent levels of precipitation at the location, and the amount of and vehicle mix of traffic on the road.

The Cost of Needed Road, Highway and Bridge Improvements

The American Association of Transportation Officials (AASHTO) found in a recent report that the current level of investment in the nation's roads, highways and bridges is inadequate to keep them from deteriorating further and to relieve traffic congestion and improve roadway safety.

The 2015 AASHTO Transportation Bottom Line Report found that the U.S. currently has a $740 billion backlog in improvements needed to restore the nation's roads, highways and bridges to the level of condition and performance needed to meet the nation's transportation demands, including a $392 billion backlog in needed road and highway repairs to return them to a state of good repair, a $112 billion backlog in needed bridge rehabilitation and a $237 billion backlog in needed highway capacity expansions to relieve traffic congestion and support economic development.[25]

Federal Role in Funding Road Repairs

The federal government is a critical source of funding for the nation's roads, highways, bridges and transit systems and provides a significant return to states in road and bridge funding based on the revenue generated in the state by the federal motor fuel tax.

Most federal funds for highway and transit improvements are provided by federal highway user fees, largely an 18.4 cents per gallon tax on gasoline and a 24.4 cents per gallon tax on diesel fuel. Since 2008 revenue into the federal Highway Trust Fund has been inadequate to support legislatively set funding levels so Congress has transferred approximately $53 billion in general funds and an additional $2 billion from a related trust fund into the federal Highway Trust Fund.[26]

Signed into law in December 2015, the Fixing America's Surface Transportation Act (FAST Act), provides modest increases in federal highway and transit spending. The five-year bill also provides states with greater funding certainty and streamlines the federal project approval process. But, the FAST Act does not provide adequate funding to meet the nation's need for highway and transit improvements and does not include a long-term and sustainable funding source.

The five-year, $305 billion FAST Act will provide approximately a 15 percent boost in highway funding and an 18 percent boost in transit funding over the duration of the program, which expires in 2020.[27] In addition to federal motor fuel tax revenues, the FAST Act will also be funded by $70 billion in U.S. general funds, which will rely on offsets from several unrelated federal programs including the Strategic Petroleum Reserve, the Federal Reserve and U.S. Customs.

According to the 2015 AASHTO Transportation Bottom Line Report, a significant boost in investment in the nation's roads, highways, bridges and public transit systems is needed to improve their condition and to meet the nation's transportation needs. The AASHTO report found that based on an annual one percent increase in VMT that annual investment in the nation's roads, highways and bridges needs to increase by

36 percent, from $88 billion to $120 billion to improve conditions and the nation's mobility needs.[28] Investment in the nation's public transit system needs to increase from $17 billion to $43 billion.[29]

The 2015 AASHTO Transportation Bottom Line Report found that if the rate of vehicle travel increased by 1.4 percent per year, the needed annual investment in the nation's roads, highways and bridges would need to increase by 64 percent, to $144 billion. If vehicle travel grows by 1.6 percent annually the needed annual investment in the nation's roads, highways and bridges would need to increase by 77 percent, to $156 billion.

operating costs, increased traffic delays and additional traffic crashes. Addressing both the capacity and deteriorating condition of our highways and roadways will be increasingly important as the nation's population is projected to increase almost 30 percent by 2050.[31]

As theeconomy continues to recover from the economic downturn, investment in roadway repairs can help support economic growth. The preservation of roads and highways improves travel speed, capacity and safety, while reducing operating costs for people and businesses.[32] Projects that preserve existing transportation infrastructure also extend the service life of a road, highway or bridge and save money by postponing or eliminating the need for more expensive future repairs.[33]

The cost of road and bridge improvements are more than offset by the reduction of user costs associated with driving on rough roads, the improvement in business productivity, the reduction in delays and the improvement in traffic safety.

The Federal Highway Administration estimates that each dollar spent on road, highway and bridge improvements results in an average benefit of $5.20 in the form of reduced vehicle maintenance costs, reduced delays, reduced fuel consumption, improved safety, reduced road and bridge maintenance costs and reduced emissions as a result of improved traffic flow.[34]

Recommendations for SmootherUrban Roads

Increasing the smoothness of urban roads, thus reducing the additional vehicle operating costs paid by motorists for driving on deteriorated roads, requires that

transportation agencies pursue an aggressive program of constructing and reconstructing roads to high smoothness standards, conducting maintenance before roadways reach unacceptable condition and using the best practices for repairing damaged pavements.

The following practices can help to provide a smooth ride on the nation's roadways.

- Implement and adequately fund a pavement preservation program that postpones the need for significant rehabilitation by performing initial maintenance and preservation on road surfaces while they are still in good condition.
- Consider using pavement materials and designs that will provide a long-lasting surface when critical routes are constructed or reconstructed
- Resurface roads in a timely fashion using pavement 9(en1(nvte)1(d)]i)-2l prsion r vc]e -2(a1(
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Endnotes

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