Saving Time, Saving Money: The Economics of Unclogging America's Worst Bottlenecks

About the American Highway Users Alliance

The American Highway Users Alliance is a nonprofit advocacy organization serving as the united voice of the transportation community promoting safe and uncongested highways and enhanced freedom of mobility. Known as The Highway Users, the group works for sound transportation policy in the United States.

Since 1932, we have fought for road and bridge improvements that will save lives, clean our air, promote economic growth, improve our quality of life, and protect our freedom of mobility.

Working with Congress, state and local governments, and the media, we promote a favorable climate for highway construction, efficient deliveries of raw materials and finished products, and tourism. Fair highway use taxation, federal highway funding, responsible environmental policy, and needed highway and bridge investments are the focus of The Highway Users' campaigns.

The Highway Users includes among its 300 members corporations, small businesses, national trade associations, and state and local nonprofit organizations that represent over 45 million highway users.

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Executive Summary

Traffic congestion is a worsening problem in many U.S. cities. A persistent and significant source of that congestion is freeway bottlenecks—specific chokepoints on major highways that routinely experience traffic backups. A 1999 study by the American Highway Users Alliance entitled *Unclogging America's Arteries: Prescriptions for Healthier Highways* identified the 166 worst bottlenecks in the country and evaluated the benefits of removing them. Specifically, improving traffic flow through those chokepoints would:

Save Lives

Traffic congestion causes highway crashes that can kill drivers and their passengers. As highway crowding increases and motorists jockey for position at exits and entryways, the potential for crashes increases. Improving bottlenecks saves lives and averts injuries.

Save the Environment

Bottlenecks retard the nation's otherwise impressive progress in improving air quality. Vehicles caught in stop-and-go traffic emit far more pollutants—carbon monoxide, volatile organic compounds, and nitrogen oxides—than they do when operating *without* frequent braking and accelerations. Improving bottlenecks reduces tailpipe pollutants.

Reduce Greenhouse Gas Emissions

Vehicles emit carbon dioxide, a greenhouse gas, as fuel is consumed. The longer they are delayed in traffic, the more fuel they consume and the more carbon dioxide they emit. Reducing delays has a direct effect on reducing greenhouse gases.

Save Time

Traffic congestion is a major source of frustration for American travelers, adding stress and inciting road rage. Reducing road delays eases that frustration and gives motorists more time for families, errands, work, and play.

Save Fuel

Idling in traffic jams not only wastes time, but burns fuel unnecessarily. While fixing traffic bottlenecks may not lower the price of gas at the pump, it certainly reduces motorists' and truckers' total fuel bill by reducing the number of times they have to fill up.

Enhance Productivity

Bottlenecks also delay product deliveries, inhibiting productivity and raising costs. Businesses suffer direct economic consequences because of congestion: in the world of "just-in-time" deliveries, time really is money. Congested roadways can also discourage businesses from bringing their business and jobs to urban areas. Improving bottlenecks boosts productivity and economic health.

The Bottom Line

The economic value of these beneficial byproducts of congestion relief is astounding. Commuters and citizens nationwide would enjoy more than $336 billion in economic benefits from improvements to the nation's worst bottlenecks. The average commuter traveling through one of these 166 worst bottlenecks twice each workday could expect to save approximately $345 each year in time and fuel alone if improvements were made.

While construction projects are planned or already under way at a handful of these sites, improvements to the vast majority of these bottlenecks may not begin for years. Unfortunately, the opportunity cost of these delays—measured in wasted time and fuel, lost lives, additional injuries, and tailpipe emissions that could have been avoided if improvements were completed now rather than later—is staggering. Specifically, a three-year delay in undertaking needed improvements to the 166 bottlenecks yields an opportunity cost, in benefits foregone, of nearly $30 billion.

By assigning monetary values to the time and fuel savings, safety improvements, and environmental benefits already identified in *Unclogging America's Arteries*, this report gives transportation officials, policy makers, and the general public a clearer understanding of the significant social and economic rewards to be reaped by improving traffic flow at key chokepoints. For each bottleneck in each metropolitan area, state and local officials must weigh the cost of improvements against the benefits to be gained once the project is complete. Savings at the remarkable levels identified in this study, and conversely, the astonishing opportunity costs of inaction, should provide ample justification to move important highway improvement projects to the forefront of the nation's transportation agenda.

Introduction

Highway traffic congestion is a major source of frustration for American travelers, causing an estimated 4.3 billion hours of delays per year in 68 of the nation's largest cities.[1] Besides adding to the frustration and stress levels of American drivers, traffic congestion also has significant economic, environmental, and safety consequences. In terms of wasted time and fuel alone, congestion cost Americans more than $72 billion in 1997.[2]

> ### Options for Relieving Congestion
>
> Alleviating congestion, even at specific bottlenecks, may require the implementation of a broad range of strategies. Smoother traffic flow might be achieved by redesigning an interchange to alleviate weaving caused by through traffic mixing with other traffic entering and exiting the highway. Operational controls, such as traffic lights on entry ramps to smooth the flow of merging traffic, can help. With most of today's commuter traffic flowing from one suburb to another rather than to the central city, new highways are often needed to provide more direct access between residential areas and employment centers. The addition of HOV (high-occupancy vehicle) lanes is another option, as is corridor access for bus or rail transit. And flexible work hours at major employment centers can reduce traffic volumes during peak hours.
>
> It is clear from past experience that no single strategy can adequately address the problems of metropolitan congestion. However, a balanced, comprehensive approach to traffic congestion can lessen the stifling gridlock found on many highways.

Unclogging America's Arteries: Prescriptions for Healthier Highways, a 1999 report performed by Cambridge Systematics, Inc., for the American Highway Users Alliance, analyzed one of the principal causes of traffic congestion—freeway bottlenecks—and the benefits to be gained by smoothing the flow of traffic through those chokepoints. The report identified the worst bottlenecks in the country and assessed the time savings, safety benefits attributable to fewer crashes, and reduced tailpipe emissions that could be obtained by improving those sites. The report included a detailed analysis of the 17 top bottlenecks[3] and an aggregate analysis of benefits to be derived if the 166 worst bottlenecks nationwide were improved.

The results were striking. By smoothing traffic flow at these specific chokepoints, the report indicated that 287,000 crashes would be avoided over 20 years, saving lives and preventing injuries. The improvements would reduce tailpipe emissions of two criteria pollutants by 45 percent and lower by 71 percent the carbon dioxide emissions[4] from vehicles traveling through the bottlenecks. In addition, the potential time savings for motorists and commercial shippers are enormous. At some of the sites studied, improvements would add as much as an hour to each traveler's day for activities other than sitting in traffic.

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[1] Lomax, Tim, and Schrank, David, *Urban Mobility Study—1997*, Texas Transportation Institute, Texas A&M University, 1999.

[2] Lomax and Schrank, 1999.

[3] Eighteen top bottlenecks were identified in *Unclogging America's Arteries*, but state officials indicated no future improvements were anticipated at the I-5/I-90 interchange in Seattle, so an analysis of potential benefits was not undertaken for that site.

[4] Although not a pollutant, carbon dioxide is known to trap heat in the Earth's atmosphere and is often referred to as a greenhouse gas.

Level of Service D Operations: Bottlenecks Where No Improvements Are Currently Planned

Of the nation's 17 worst bottlenecks identified in *Unclogging America's Arteries,* improvements are planned or already under way at 7 sites. No specific improvements have been designed at the remaining sites.

To assess the potential benefits of improvements in those cases in which no specific improvement project has been identified, the report assumed a hypothetical improvement that would bring traffic flow up to a minimally acceptable level. The scale of this improvement would increase capacity to a point at which the facility would operate at level of service D. Level of service is a concept that traffic engineers have devised to describe how well highway facilities operate. Six level-of-service categories are used: A, B, C, D, E, and F. In layman's terms, they roughly correspond to the letter grades used in education. On freeways, level of service A is free-flow conditions characterized by high speeds and wide spaces between vehicles. As level of service goes from B to D, speeds stay high but vehicle spacing decreases. At level of service E, the physical capacity of the roadway is reached; the highest traffic flows are observed and speeds start to fall off sharply. Level of service F is stop-and-go traffic. Highway improvements typically are designed to produce level of service C or D operations once the project is completed.

This report, *Saving Time, Saving Money: The Economics of Unclogging America's Worst Bottlenecks*, assesses the economic impact of the impressive gains from bottleneck improvements identified in *Unclogging America's Arteries*. By assigning monetary values to the time and fuel savings, safety improvements, and environmental benefits already identified, we hope to give transportation officials, policy makers, and the public a clearer understanding of the significant social and economic rewards to be reaped by improving traffic flow at key chokepoints.

Saving Time, Saving Money is divided into two sections. **Chapter One** identifies the total economic benefits to be derived from bottleneck improvements. The economic values listed in each of the bottleneck case studies are cumulative over the construction period and a 20-year useful life of the project. In addition, we identify what the cumulative savings of time and fuel would mean in annual savings for a typical commuter traveling through the bottleneck twice each workday.

Chapter Two is an analysis of the opportunity costs involved in delaying improvements at these bottlenecks. Construction projects are planned or already under way at some of the 17 worst bottlenecks analyzed in this report, but for a majority of the bottleneck sites, improvements may not be undertaken for years. Delays may be attributable to a lack of financial resources, the absence of local consensus on appropriate solutions, regulatory hurdles, litigation involving a proposed improvement, or a host of other reasons. The analysis in Chapter Two identifies the cost of those delays, measured in terms of wasted time and fuel, lost lives, additional injuries, and tailpipe emissions that could be avoided if the improvements were completed now rather than later.

Saving Time, Saving Money identifies the benefits to be realized if America's worst bottlenecks are eliminated and, conversely, the price to be paid if nothing were done. For each bottleneck in each metropolitan area, state and local officials must weigh the cost of improvements against the benefits to be gained once the project is complete. This study should help illuminate the significant benefits that can be obtained by opening bottlenecks on our most congested freeways.

Chapter One: Economic Benefits

Chapter One of this report provides detailed case studies on the economic benefits of completing improvements to the 17 worst freeway bottlenecks in the United States. The chapter begins with a table showing the lifetime and annualized benefits of improving each bottleneck. That table is followed by a national case study assessing the benefits of improving 166 identified freeway bottlenecks, including the 17 worst. The economic benefits of the improvements are enumerated in a benefits box for each case study. These benefits[1] are provided in year 2000 dollars and are cumulative over the multiyear construction period and 20-year useful life of each project.

Personal Time Savings

The value of reduced travel delays to commuters, using $6 per hour as the value of time spent in personal travel.

Commercial Time Savings

The value of reduced travel delays for commercial vehicles, estimated at $48 per hour. This figure includes the value of the operator's time plus nonfuel operating costs of $2.40 per mile and an average speed of 20 mph.

Fuel Savings

The value of reduced travel delays in terms of fuel saved using a share-weighted average of gasoline and diesel fuel prices, including taxes, which are expected to prevail over the next two decades. This figure, $1.40 per gallon, may be a conservative estimate.

Safety Savings

The value of accidents forestalled by improvements to bottlenecks. These savings are expressed in terms of the value of crashes avoided, at an average of $95,000 per crash, using valuations of $4.8 million for fatal crashes and $150,000 for crashes with injuries.

Environmental Savings

The value of reducing both greenhouse gases and air pollution. Greenhouse gas savings are the result of a reduction in carbon dioxide emissions from improved traffic flow. Air pollution savings result from the reduction in emissions of three major air pollutants: carbon monoxide, nitrogen oxides, and volatile organic compounds. Greenhouse gas benefits are calculated using a carbon price of $75 per ton. Air pollution benefits are calculated using values of carbon monoxide at $0.25 per pound, nitrogen oxides at $1.50 per pound, and volatile organic compounds at $0.50 per pound, except for four major sites in Los Angeles, where these values are tripled.

Total Savings

The total economic impact of improving traffic flow through a particular bottleneck over both a multiyear construction period and the 20-year useful life of the improvement. This figure is the sum of the time, fuel, safety, and environmental savings identified in the analysis.

[1] For a detailed discussion of methodology, see Appendix A.

You Save

The annual savings for commuters traveling through the bottleneck twice each workday should the improvements be completed. It is calculated by combining estimated savings of time and fuel costs over the useful life of the project.

Freeway Bottlenecks: Key To Reducing Congestion Costs

Table 1 recaps the economic benefits in year 2000 dollars from projects to unclog the nation's worst bottlenecks over the project lifetimes and on an annualized basis. The annualized benefits of the top 17 projects aggregate to about $5.5 billion, and improvements to all 166 projects yield annualized benefits of about $14.5 billion. These estimates may be compared with the annualized costs of traffic congestion, estimated recently by the Texas Transportation Institute (TTI) as ranging from $70 to $75 billion for 68 of the nation's largest cities. Allowing for the higher value of personal travel time used in the TTI study, it may be inferred that improving the top 17 bottlenecks would eliminate roughly one-tenth of the nation's annual congestion cost, and fixing all 166 bottlenecks would eliminate about two-tenths.

Table 1. Economic Benefits of Unclogging America's Worst Bottlenecks (2000$)

Project	Project Life Benefits	Annualized Benefits
I-495/I-270 (MD)	13,353,000,000	581,000,000
US-59/I-610 (TX)	10,567,000,000	459,000,000
I-40/I-25 (NM)	10,094,000,000	459,000,000
I-95/I-495 (VA)	9,984,000,000	344,000,000
I-285/I-85 (GA)	9,806,000,000	426,000,000
SR-55/SR-22 (CA)	8,650,000,000	376,000,000
I-285/I-75 (GA)	7,883,000,000	343,000,000
I-93, Central Artery (MA)	7,179,000,000	299,000,000
I-610/I-10 (TX)	6,986,000,000	304,000,000
US-101/I-405 (CA)	6,479,000,000	282,000,000
I-95/I-495 (MD)	6,138,000,000	267,000,000
I-75/I-85 (GA)	5,988,000,000	260,000,000
I-10/I-5 (CA)	5,775,000,000	251,000,000
I-405/I-10 (CA)	5,468,000,000	249,000,000
I-66/I-495 (VA)	5,153,000,000	224,000,000
I-25/I-225 (CO)	4,565,000,000	163,000,000
I-290/I-88/I-294 (IL)	4,224,000,000	192,000,000
Subtotal: 17 Worst Bottlenecks	128,293,000,000	5,479,000,000
All 166 Bottlenecks	335,656,000,000	14,594,000,000

Notes: Detail may not add to total because of rounding; I-95 project life is 28 years, I-25/I-225 project life is 28 years, Central Artery project life is 24 years, and I-405, I-290 project lives are 22 years, versus 23 years for others.

Sources: *Unclogging America's Arteries;* data provided by Cambridge Systematics, Inc.; and author's calculations.

National Analysis

Summary

Commuters and citizens nationwide would enjoy more than $336 billion in economic benefits from improvements to the nation's worst bottlenecks. The average commuter traveling through one of these 166 worst bottlenecks twice each workday could expect to save approximately $345 each year in time and fuel alone.

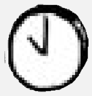
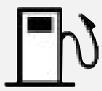
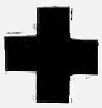
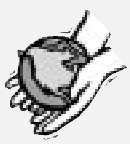
Bottleneck Description

Unclogging America's Arteries: Prescriptions for Healthier Highways identified the 166 worst freeway bottlenecks in the United States, based on an analysis of the Highway Performance Monitoring System (HPMS) database. The HPMS data, including information on the traffic and physical characteristics of the nation's highways, are reported to the Federal Highway Administration annually. Each of these bottlenecks is responsible for at least 700,000 hours of commuter delay annually.

Costs vs. Benefits

In numerous cases, no specific improvements have been designed at the bottlenecks we analyzed, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. Nationwide, the benefits of improving the nation's worst bottlenecks are estimated to be over $14 billion per year. Savings at such an astounding level should provide ample justification to move important highway improvement projects to the forefront of the nation's transportation agenda.

Assuming an average 3-year construction period and a 20-year useful life for all potential projects, improving traffic flow at the nation's worst bottlenecks to level of service D[2] operations will generate more than $336 billion in economic benefits.

Personal Time Savings	**$183 billion**
Commercial Time Savings	**$77 billion**
Fuel Savings	**$28 billion**
Safety Savings	**$27 billion**
Environmental Savings	
Greenhouse Gases:	**$15 billion**
Air Pollution:	**$6 billion**
Total Savings	**$336 billion**

[2] See explanation of level of service D operations on page 4.

Albuquerque, New Mexico

I-40 at the I-25 Interchange: The "Big I"

Summary

Albuquerque commuters and residents will reap more than $10 billion in economic benefits from the planned improvements to the "Big I." The average commuter traveling through this bottleneck twice each workday will save approximately $1,370 per year in time and fuel alone.

Bottleneck Description

So called because it resembles a giant eye when viewed from the air, the Big I is the junction of Interstate 25 and Interstate 40 near Albuquerque's downtown district. These two highways are vital to both the regional and local transportation systems. At the regional level, both I-25 and I-40 are primary routes used for interstate travel and goods shipment. I-25 serves as the primary highway connecting the international border area of the United States and Mexico with I-10, I-40, SR-70, and other regional highways used for travel and transporting goods within and across the southwestern United States. I-40 is a transcontinental highway extending from California to North Carolina and is heavily used for commercial goods transport and by interstate travelers.

It is estimated that one of every three trips taken in the Albuquerque region passes through the Big I. The current structures at the interchange are over 30 years old and approaching the point at which major reconstruction will be needed just to keep the existing overpasses and ramps in safe physical condition.

Costs vs. Benefits

The "Big I" project may represent the biggest bargain among the 6 planned and 11 potential improvement projects in this study. The improvements to the "Big I" are expected to take only two years and cost about $210 million. The benefits over the project's lifetime are estimated at more than $10 billion, or more than $450 million per year.

The value of time savings to businesses alone is estimated at $2.4 billion over 22 years. Improvements to the "Big I" are critical because I-40 is a major route for freight transport between California and points east. Reducing this bottleneck will have benefits that extend beyond New Mexico in terms of lowered prices for goods shipped long distance over this route. Finally, the value of reduced air pollution from this project is estimated at $220 million over 22 years; as a result, the gains in cleaner air alone appear to justify the project's $210 million price tag.

The Economic Benefits of Improvements: 2000–2021

Over the 2-year construction period and the 20-year life of the project, the improvements to the "Big I," already under way, will generate more than $10 billion in economic benefits.

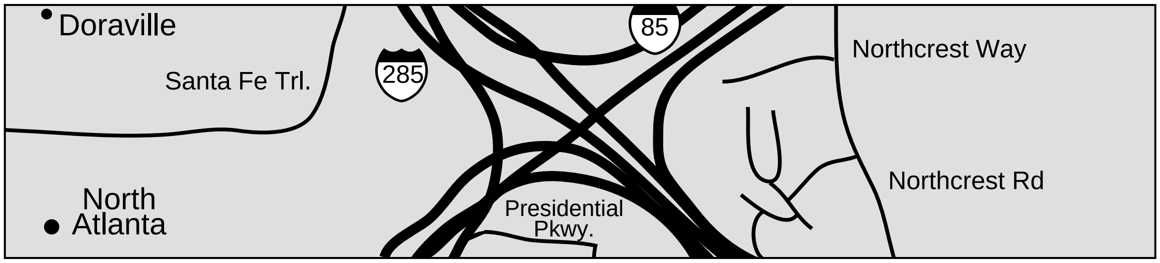
Personal Time Savings	**$5.7 billion**
Commercial Time Savings	**$2.4 billion**
Fuel Savings	**$870 million**
Safety Savings	**$460 million**
Environmental Savings	
Greenhouse Gases:	**$450 million**
Air Pollution:	**$220 million**
Total Savings	**$10.1 billion**

You Save: $1,370 per year

(Average annual savings for a commuter using the bottleneck)

Atlanta, Georgia

I-285 at the I-85 Interchange



Summary

Atlanta area residents and commuters stand to reap $9.8 billion in economic benefits if needed improvements at the I-285 and I-85 interchange are implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $1,013 each year in time and fuel alone.

Bottleneck Description

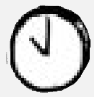
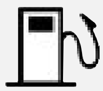
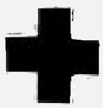
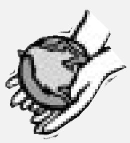
I-285 and I-85 intersect in De Kalb County about 15 miles northeast of downtown Atlanta. I-85 serves both as a commuter route and as a major intercity route for the southeastern United States. The area around the interchange has undergone rapid growth during the past decade, and this trend is expected to continue. The Georgia DOT recognizes the severity of traffic congestion at this site, but no specific improvements to the I-285/I-85 interchange are planned at this time.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $420 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the I-285/I-85 interchange up to level of service D operations[3] would generate approximately $9.8 billion in economic benefits.

Personal Time Savings	**$5.4 billion**
Commercial Time Savings	**$2.3 billion**
Fuel Savings	**$820 million**
Safety Savings	**$660 million**
Environmental Savings	
Greenhouse Gases:	**$430 million**
Air Pollution:	**$220 million**
Total Savings	**$9.8 billion**

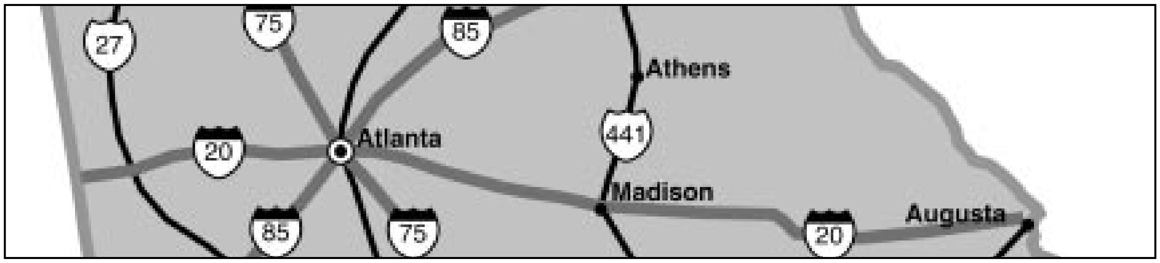
[3] See explanation of level of service D operations on page 4.

You Save: $1,013 per year

(Average annual savings for commuters using the bottleneck)

Atlanta, Georgia

I-75 at the I-85 Interchange



Summary

Atlanta area residents and commuters stand to reap $6 billion in economic benefits if needed improvements at the I-75 and I-85 interchange are implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $752 each year in time and fuel alone.

Bottleneck Description

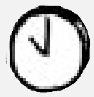
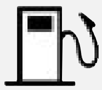
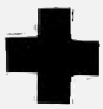
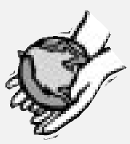
I-75 and I-85 intersect about three miles north of downtown Atlanta. The area just south of the interchange, where the interstates run parallel to one another, has the highest traffic volume of any U.S. freeway: 389,000 vehicles per day on 14 lanes of traffic. The Georgia DOT recognizes the severity of traffic congestion at this site, but no specific improvements to the I-75/I-85 interchange are planned at this time.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $260 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the I-75/I-85 interchange up to level of service D operations[4] would generate approximately $6.0 billion in economic benefits.

Personal Time Savings	**$3.3 billion**
Commercial Time Savings	**$1.4 billion**
Fuel Savings	**$500 million**
Safety Savings	**$460 million**
Environmental Savings	
Greenhouse Gases:	**$260 million**
Air Pollution:	**$130 million**
Total Savings	**$6.0 billion**

[4] See explanation of level of service D operations on page 4.

You Save: $752 per year

(Average annual savings for commuters using the bottleneck)

Atlanta, Georgia

I-285 at the I-75 Interchange

Summary

Atlanta area residents and commuters stand to reap $7.8 billion in economic benefits if needed improvements at the I-285 and I-75 interchange are implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $945 each year in time and fuel alone.

Bottleneck Description

I-285 serves as the beltway for the Atlanta region. It intersects with I-75 about 10 miles from downtown Atlanta. The I-75 corridor north of the interchange is heavily developed and is expected to continue to grow rapidly. The Georgia DOT recognizes the severity of traffic congestion at this site, but no specific improvements to the I-285/I-75 interchange are planned at this time.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $300 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the I-285/I-75 interchange up to level of service D operations[5] would generate approximately $7.8 billion in economic benefits.

Personal Time Savings	**$4.3 billion**
Commercial Time Savings	**$1.8 billion**
Fuel Savings	**$660 million**
Safety Savings	**$550 million**
Environmental Savings	
Greenhouse Gases:	**$340 million**
Air Pollution:	**$170 million**
Total Savings	**$7.8 billion**

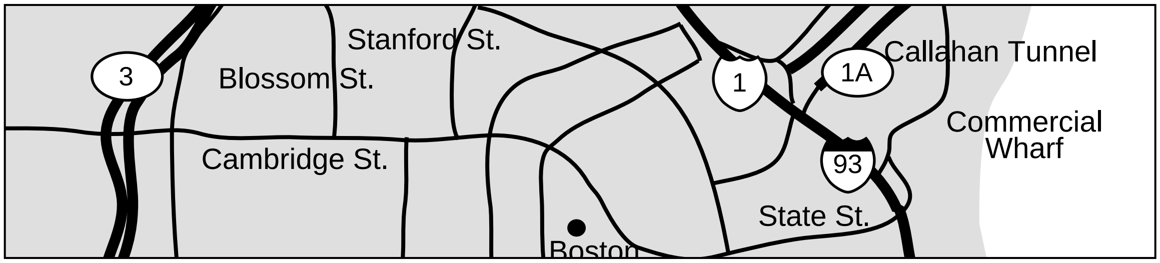
[5] See explanation of level of service D operations on page 4.

You Save: $945 per year

(Average annual savings for commuters using the bottleneck)

Boston, Massachusetts

I-93 (Central Artery) in Downtown Boston: The "Big Dig"



Summary

The completion of the "Big Dig," one of the most complex highway and urban renewal projects in American history, will result in $7.2 billion in economic savings over the useful life of the project. Boston area commuters traveling on the Central Artery twice each workday will save approximately $1,010 per year in time and fuel alone.

Bottleneck Description

The original section of I-93 was constructed as an elevated six-lane highway called the Central Artery, which runs through the center of downtown Boston. When it opened in 1959, the Central Artery comfortably carried about 75,000 vehicles a day. Today it carries as many as 223,300 vehicles daily, resulting in long periods of congestion. I-93 is a major commuter route into downtown Boston from the northern suburbs.

Costs vs. Benefits

At first glance, the costs for completing the Big Dig, expected to reach $13.1 billion, appear to exceed the potential economic benefits estimated by this study at $7.2 billion. However, the Big Dig is far more than a standard highway project; it is also one of the largest, most expensive urban renewal projects in American history. The transportation elements of the project include replacing an elevated 6-lane highway with a new 8- to 10-lane underground expressway, adding new bridge capacity, and creating parking facilities. But the project also includes city landscaping, substantial historic preservation projects, and the creation of 150 acres of new open space for parks and business. While assessment of the economic value of these important non-transportation elements is beyond the scope of this study, they clearly have value which, if quantified, would add significantly to the total economic benefits of the project. Further, this study uses a conservative estimate of the value of time for personal travelers ($6.00/hr). If raised to an industry-accepted norm ($12.00/hr), the economic benefits of this project would increase to $11.2 billion.

The Economic Benefits of Improvements: 2000–2023

Over the remaining 4-year construction period and the 20-year life of the project, the improvements to the Big Dig, already under way, will generate more than $7 billion in economic benefits.

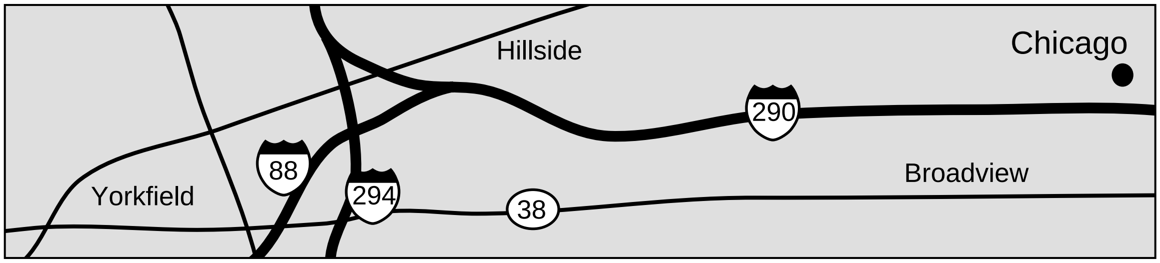
Personal Time Savings	**$4 billion**
Commercial Time Savings	**$1.7 billion**
Fuel Savings	**$610 million**
Safety Savings	**$430 million**
Environmental Savings	
Greenhouse Gases:	**$320 million**
Air Pollution:	**$130 million**
Total Savings	**$7.2 billion**

You Save: $1,010 per year

(Average annual savings for commuters using the bottleneck)

Chicago, Illinois

I-290 at the Interchange of I-88 and I-294: The "Hillside Strangler"



Summary

Chicago commuters and residents tangling with the "Hillside Strangler" stand to reap more than $4 billion in economic benefits from the planned improvements to this bottleneck. The average commuter traveling through this bottleneck twice each workday will save approximately $658 each year in time and fuel alone.

Bottleneck Description

The name "Hillside Strangler" comes from the nearby town of Hillside and the convoluted tangle of three intersecting freeways and several local streets that make up the interchange. The design of I-290 was completed in the early 1950s and does not meet the current design standards for freeways. A significant problem with the configuration of the I-290 interchange area is a lack of lane balance: Eight eastbound lanes approaching the interchange from the west must merge to only three lanes on I-290.

Costs vs. Benefits

Improvements to the Hillside Strangler represent another bargain among the 17 projects nationwide. The series of improvements to I-290 at the interchange of I-88 and I-294 near Chicago are expected to take 2 years and cost $110 million to complete. By contrast, the economic benefits of this project are expected to exceed $192 million per year, for a total benefit over the useful life of the project of $4.2 billion. Over its lifetime, this project is expected to result in 2,746 fewer crashes, valued at roughly $260 million. The safety benefits alone are valued at more than twice the cost of the project.

The Economic Benefits of Improvements: 2000–2021

Over the 2-year construction period and the 20-year useful life of the project, the planned improvements to the Hillside Strangler will generate more than $4 billion in economic benefits.

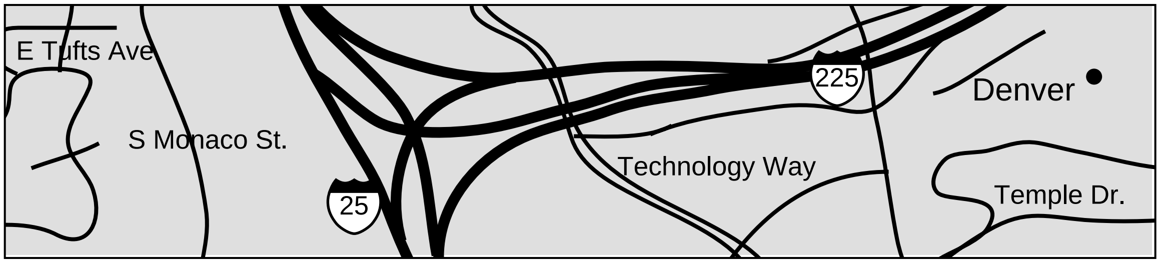
Personal Time Savings	**$2.4 billion**
Commercial Time Savings	**$1 billion**
Fuel Savings	**$360 million**
Safety Savings	**$260 million**
Environmental Savings	
Greenhouse Gases:	**$190 million**
Air Pollution:	**$75 million**
Total Savings	**$4.2 billion**

You Save: $658 per year

(Average annual savings for commuters using the bottleneck)

Denver, Colorado

I-25 at the I-225 Interchange: The Tech Center Interchange



Summary

Denver commuters and residents will reap more than $4 billion in economic benefits from the planned improvements to the Tech Center Interchange (I-25 at the I-225 interchange). The average commuter traveling through this bottleneck twice each workday will save approximately $615 each year in time and fuel alone.

Bottleneck Description

The Southeast Corridor has long been recognized as one of the Denver region's highest priority travel corridors. With the region's two largest employment centers at either end, it is the highest volume, most congested corridor in Denver. Located approximately in the middle of the corridor is the I-25/I-225 interchange. According to Colorado DOT information, I-25 currently experiences "severe congestion" for several miles on either side of the interchange, and I-225 experiences "moderate congestion."

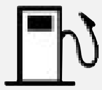
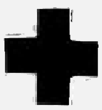
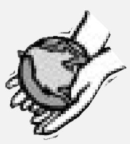
The proposed improvements in the Southeast Corridor include projects on two interstate highways and the addition of a light rail transit line. The highway projects include improvements to eight interchanges (I-25/I-225 is the major interchange) and the addition of lanes, shoulders, and other features on both interstates.

Costs vs. Benefits

The improvements planned for the I-25/I-225 Interchange near Denver represent a very good deal from an economic standpoint. The planned highway improvements to the entire Southeast Corridor are expected to cost $600 million and take approximately 7 years to complete. The lifetime economic benefits of improvements to the I-25/I-225 interchange alone are estimated at $4.5 billion, or roughly $160 million per year. The estimated savings of $700 million in safety and environmental benefits alone over the life of the I-25/I-225 interchange should more than cover the cost of all highway improvements planned for the Southeast Corridor.

The Economic Benefits of Improvements: 2000–2026

Over the 7-year construction period and the 20-year life of the project, the planned improvements to the Tech Center Interchange will generate more than $4 billion in economic benefits.

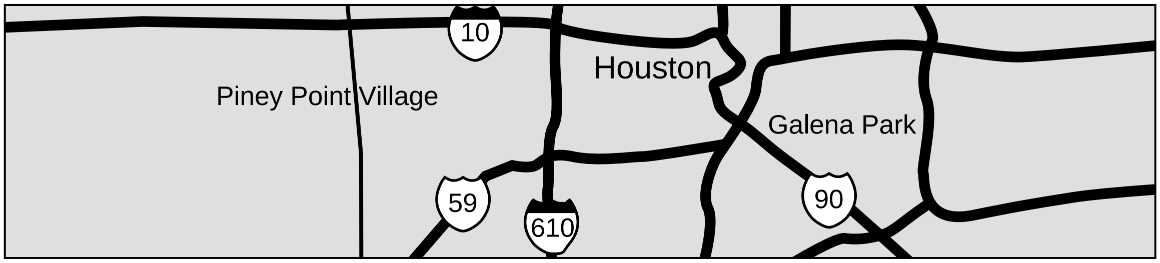
Personal Time Savings	**$2.4 billion**
Commercial Time Savings	**$1.0 billion**
Fuel Savings	**$370 million**
Safety Savings	**$440 million**
Environmental Savings	
Greenhouse Gases:	**$190 million**
Air Pollution:	**$82 million**
Total Savings	**$4.5 billion**

You Save: $615 per year

(Average annual savings for commuters using the bottleneck)

Houston, Texas

US-59 (Southwest Freeway) at the I-610 Loop Interchange



Summary

Houston area residents would reap $11 billion in economic benefits if needed improvements at the US-59 and I-610 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $954 annually in time and fuel alone.

Bottleneck Description

US-59, known locally as the Southwest Freeway, runs from Laredo on the Mexican border through the center of downtown Houston. It is heavily used by local and through traffic and, as a North American Free Trade Agreement trade corridor linking Mexico, the industrial northeastern United States, and Canada, it carries a significant amount of truck traffic. It is also a major commuter route between Fort Bend County and Houston. Fort Bend is projected to grow at a rate faster than the rest of the region over the next 20 years. Traffic volumes on US-59 through the interchange are the second highest in the country. I-610 was Houston's original "beltway." With the construction of the Sam Houston Parkway—a perimeter highway farther out—I-610 now serves as an inner beltway.

Costs vs. Benefits

Certain improvements were made to this interchange when the Southwest Freeway was expanded in the early 1990s. However, until improvements are made on I-610 West Loop, motorists will realize no benefits. Design work for this interchange is in the early stages of development, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $450 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the US-59/I-610 interchange up to level of service D operations[6] would generate $11 billion in economic benefits.

Personal Time Savings	**$5.8 billion**
Commercial Time Savings	**$2.5 billion**
Fuel Savings	**$890 million**
Safety Savings	**$710 million**
Environmental Savings	
Greenhouse Gases:	**$460 million**
Air Pollution:	**$240 million**
Total Savings	**$11 billion**

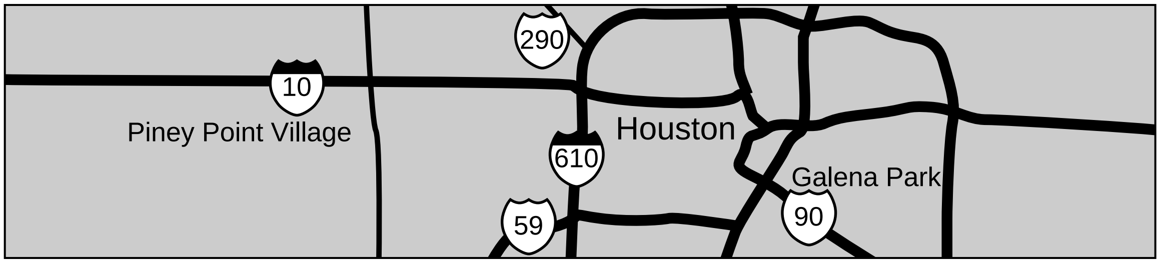
[6] See explanation of level of service D operations on page 4.

You Save: $954 per year

(Average annual savings for commuters using the bottleneck)

Houston, Texas

I-610 Loop at the I-10 Interchange



Summary

Houston area residents would reap $7 billion in economic benefits if needed improvements at the I-610 and I-10 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $788 annually in time and fuel alone.

Bottleneck Description

I-610 was Houston's original "beltway." With the construction of the Sam Houston Parkway—a perimeter highway further out—it now serves as an inner beltway. I-10, known locally as the Katy Freeway, is one of the nation's major east-west interstates, running from California to Florida. It is also a major commuter route to downtown Houston from both eastern and western suburbs.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $300 million annually.

Allowing for a 3-year construction period and a 20-year project life, bringing the I-610/I-10 interchange up to level of service D operations[7] would generate $7 billion in economic benefits.

Personal Time Savings	**$3.8 billion**
Commercial Time Savings	**$1.6 billion**
Fuel Savings	**$580 million**
Safety Savings	**$540 million**
Environmental Savings	
Greenhouse Gases:	**$300 million**
Air Pollution:	**$140 million**
Total Savings	**$7 billion**

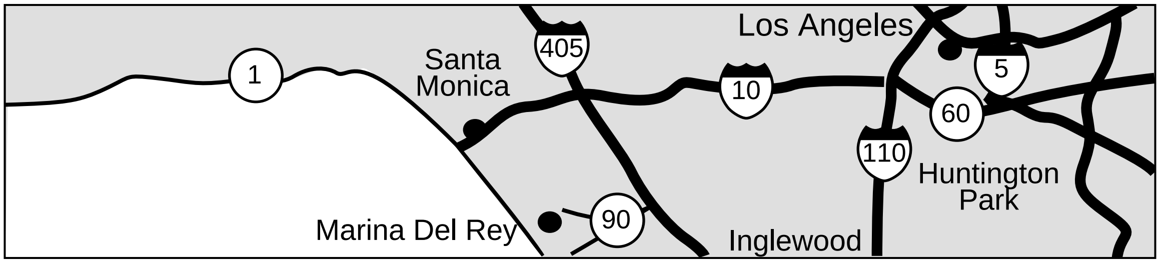
[7] See explanation of level of service D operations on page 4.

You Save: $788 per year

(Average annual savings for commuters using the bottleneck)

Los Angeles, California

I-405 (San Diego Freeway) at the I-10 Interchange



Summary

Los Angeles commuters and residents will enjoy more than $5 billion in economic benefits from the planned improvements to I-405. The average commuter traveling through this bottleneck twice each workday will save approximately $581 each year in time and fuel alone.

Bottleneck Description

I-405, also known as the San Diego Freeway, connects to I-5 both north and south of Los Angeles and is a major access route for the coastal communities in the Los Angeles area. I-10 intersects with I-405 only a few miles from its western terminus in Santa Monica. The California DOT (Caltrans) District 7 estimates that the 11-mile segment of I-405 between I-10 and US-101 experiences congestion for almost five hours every weekday afternoon.

The most recent federal Transportation Improvement Program from the Southern California Association of Governments identifies the addition of an HOV lane in each direction on I-405 on both sides of the interchange. The project is expected to start in 2000 and last two years.

Costs vs. Benefits

Although the costs to complete the HOV lanes are unknown at this time, the benefits to commuters, businesses, and the general public are estimated to be over $250 million annually. Savings at such a significant level should make this project a true bargain for the area's taxpaying commuters.

The Economic Benefits of Improvements: 2000–2022

Over the planned 2-year construction period and the 20-year life of the project, the improvements to the I-405/I-10 interchange will generate more than $5 billion in economic benefits.

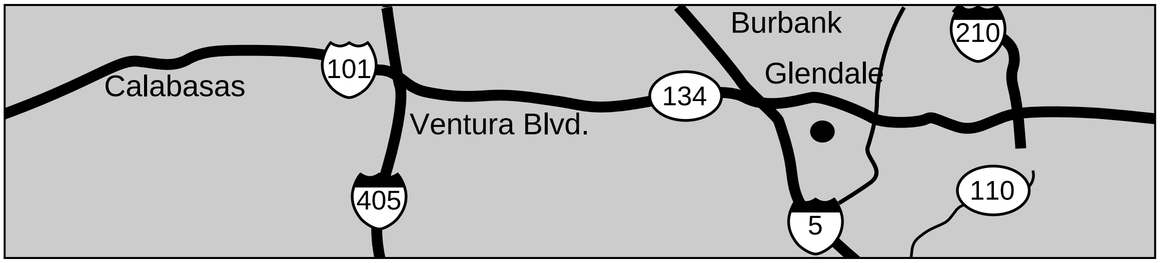
Personal Time Savings	**$2.8 billion**
Commercial Time Savings	**$1.2 billion**
Fuel Savings	**$430 million**
Safety Savings	**$430 million**
Environmental Savings	
Greenhouse Gases:	**$230 million**
Air Pollution:	**$350 million**
Total Savings	**$5.4 billion**

You Save: $581 per year

(Average annual savings for commuters using the bottleneck)

Los Angeles, California

US-101 (Ventura Freeway) at the I-405 Interchange



Summary

Los Angeles area residents would reap more than $6 billion in economic benefits if needed improvements at the US-101 and I-405 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $711 annually in time and fuel alone.

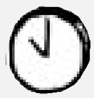
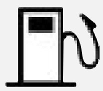
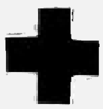
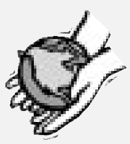
Bottleneck Description

The US-101/I-405 interchange is located in the San Fernando Valley area north of Beverly Hills. Commuters from the west and north destined for downtown Los Angeles must pass through this area. Caltrans District 7 estimates traffic is congested in this area for nearly five hours every weekday afternoon.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $280 million annually.

Allowing for a 3-year construction period and a 20-year project life, bringing the US-101/I-405 interchange up to level of service D operations[8] would generate more than $6 billion in economic benefits.

Personal Time Savings	**$3.4 billion**
Commercial Time Savings	**$1.4 billion**
Fuel Savings	**$520 million**
Safety Savings	**$500 million**
Environmental Savings	
Greenhouse Gases:	**$270 million**
Air Pollution:	**$380 million**
Total Savings	**$6.5 billion**

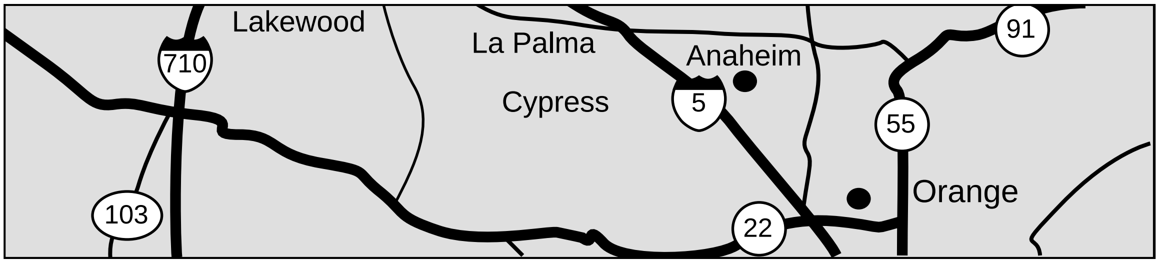
[8] See explanation of level of service D operations on page 4.

You Save: $711 per year

(Average annual savings for commuters using the bottleneck)

Los Angeles, California

State Route 55 (Costa Mesa Freeway) at the State Route 22 Interchange



Summary

Los Angeles area residents will reap $8.6 billion in economic benefits from improvements at the SR-55 and SR-22 interchange. The average commuter traveling through this bottleneck twice each workday will save approximately $1,127 annually in time and fuel alone.

Bottleneck Description

The SR-55/SR-22 interchange is located on the border of the cities of Orange and Santa Ana in Orange County. SR-55 links to SR-91 about five miles north of the interchange; together they represent a major commuter route from the San Bernardino-Riverside area to the commercial districts of coastal Orange County. Caltrans District 7 estimates that an eight-mile segment through the SR-55/SR-22 interchange area is congested for four and a half hours every weekday afternoon.

The most recent federal Transportation Improvement Program from the Southern California Association of Governments recommends the addition of HOV lanes on SR-55 from the SR-22 interchange to the junction with SR-91. This work is already under way and should be completed this year.

Costs vs. Benefits

Although the costs to complete the HOV lanes are not known at this time, the benefits to commuters, businesses, and the general public are estimated to be over $370 million annually. Savings at such a significant level should make this project a true bargain for the area's taxpaying commuters.

The Economic Benefits of Improvements: 2000–2022

Over the 3-year construction period and the 20-year project life, improvements to the SR-55/SR-22 interchange will generate $8.6 billion in economic benefits.

Personal Time Savings	**$4.6 billion**
Commercial Time Savings	**$1.9 billion**
Fuel Savings	**$700 million**
Safety Savings	**$530 million**
Environmental Savings	
Greenhouse Gases:	**$360 million**
Air Pollution:	**$540 million**
Total Savings	**$8.6 billion**

You Save: $1,127 per year

(Average annual savings for commuters using the bottleneck)

Los Angeles, California

I-10 (Santa Monica Freeway) at the I-5 Interchange

Summary

Los Angeles area residents would reap nearly $6 billion in economic benefits if needed improvements at the I-10 and I-5 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $570 annually in time and fuel alone.

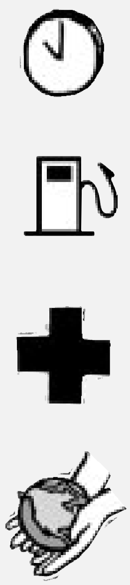
Bottleneck Description

The I-10/I-5 interchange is located on the eastern edge of the City of Los Angeles in an area where many freeways converge. Dodger Stadium, the University of Southern California, and the Civic Center are all in close proximity to the interchange. Caltrans District 7 estimates that traffic is congested in this area for four hours every weekday afternoon.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $250 million annually.

Allowing for a 3-year construction period and a 20-year project life, bringing the I-10/I-5 interchange up to level of service D operations[9] would generate nearly $6 billion in economic benefits.



Personal Time Savings	**$3.0 billion**
Commercial Time Savings	**$1.3 billion**
Fuel Savings	**$460 million**
Safety Savings	**$460 million**
Environmental Savings	
Greenhouse Gases:	**$240 million**
Air Pollution:	**$330 million**
Total Savings	**$5.8 billion**

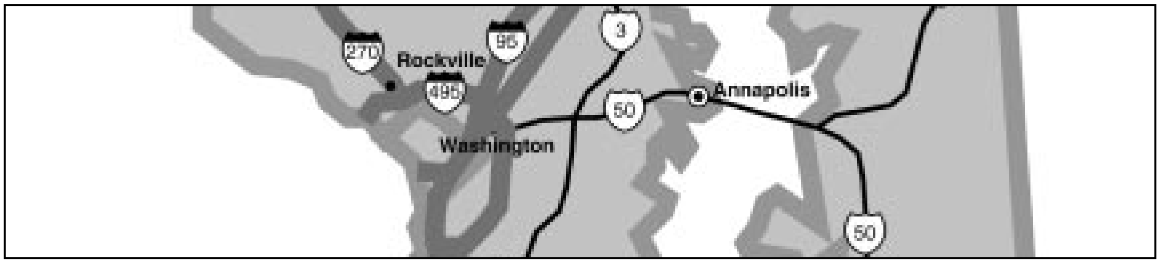
[9] See explanation of level of service D operations on page 4.

You Save: $570 per year

(Average annual savings for commuters using the bottleneck)

Washington, DC/Maryland

I-495 (Capital Beltway) at the I-270 Interchange



Summary

Washington area residents would reap over $13 billion in economic benefits if needed improvements at the I-495 and I-270 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $1,353 annually in time and fuel alone.

Bottleneck Description

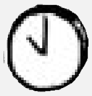
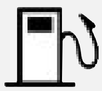
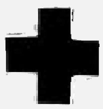
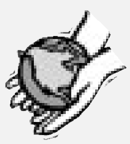
I-495, the Capital Beltway, is the beltway for the Washington, DC, area, crossing through both Maryland and Virginia. I-270 terminates where it meets I-495 and runs northwest to Frederick, Maryland. It is a major commuter corridor that has experienced—and is expected to continue experiencing—rapid growth. I-270 has two "branches" where it intersects with I-495; the western branch is the I-270 spur, which connects with I-495 more than two miles from the main interchange of I-495 and I-270. Even with this bifurcation, traffic volumes at the I-495/I-270 interchange are extremely high. The problem is compounded by the nearby interchange of Wisconsin Avenue (SR-355).

Costs vs. Benefits

In terms of benefits, this is the most valuable project of the 17 potential improvements in this study. A modest improvement raising the service level from F ("stop-and-go") to D ("dense but moving") would reduce cumulative hours of delay over a 23-year project life by 1.3 billion. Such an improvement would also save 800 million gallons of fuel, prevent 8,618 crashes (including 4,230 injuries and 34 fatalities), and remove a half million tons of pollutants and 7 million tons of carbon dioxide from the air.

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $581 million annually. The fuel savings alone may suffice to justify the cost of upgrading this interchange.

Allowing for a 3-year construction period and a 20-year project life, bringing the I-495/I-270 interchange up to level of service D operations[10] would generate more than $13 billion in economic benefits.

Personal Time Savings	**$7.4 billion**
Commercial Time Savings	**$3.1 billion**
Fuel Savings	**$1.1 billion**
Safety Savings	**$820 million**
Environmental Savings	
Greenhouse Gases:	**$590 million**
Air Pollution:	**$290 million**
Total Savings	**$13.3 billion**

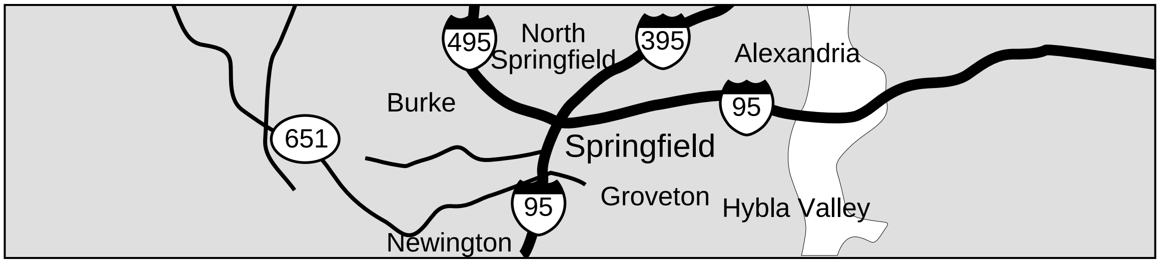
[10] See explanation of level of service D operations on page 4.

You Save: $1,353 per year

(Average annual savings for commuters using the bottleneck)

Washington, DC/Virginia

I-95 at the I-495 Springfield Interchange: "The Mixing Bowl"



Summary

With improvements to "The Mixing Bowl" already under way, the Washington area can expect to enjoy approximately $10 billion in economic benefits over the next 28 years. Once the project is completed, the average commuter traveling through this bottleneck twice each workday will save approximately $959 each year in time and fuel alone.

Bottleneck Description

Known locally as The Mixing Bowl (for its complex configuration of ramps and traffic movements), the Springfield interchange is located about 10 miles south of downtown Washington, DC. I-95, a major intercity corridor, intersects with I-495 (the Capital Beltway), and the two interstates continue together eastward into Maryland. Nearby, I-395 (Shirley Highway) takes traffic from I-95 and I-495 north into Washington, DC. The Springfield interchange was built in 1964 with the construction of the Capital Beltway. Since that time, the area has undergone rapid development, which has contributed significantly to congestion.

Costs vs. Benefits

The Mixing Bowl improvement project is another bargain among the 17 bottlenecks analyzed in this study. The cost of this project is estimated at $350 million. The total benefits over the life of the project are estimated at $10 billion, or $344 million per year on average. Therefore, the net benefits are approximately $9.6 billion, and the payback period is little more than one year. The fuel savings alone are more than double the cost of this project over its lifetime, and the benefits of reduced carbon dioxide emissions by themselves exceed the cost of the project.

The Economic Benefits of Improvements: 2000–2027

Over the 8-year construction period and the 20-year life of the project, the improvements to the Mixing Bowl, already under way, will generate approximately $10 billion in economic benefits.

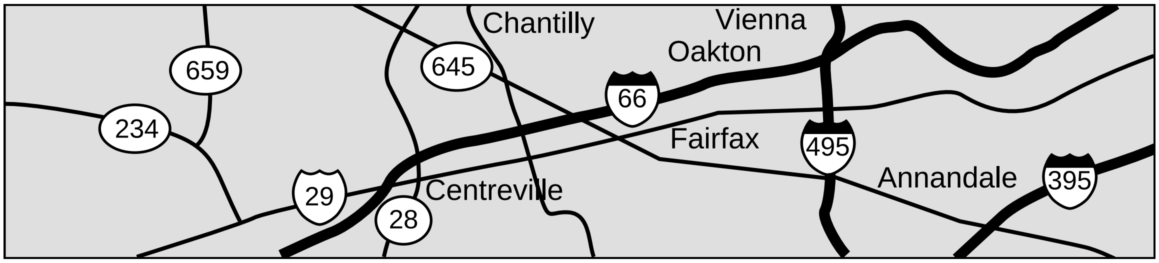
Personal Time Savings	**$5.6 billion**
Commercial Time Savings	**$2.4 billion**
Fuel Savings	**$850 million**
Safety Savings	**$590 million**
Environmental Savings	
Greenhouse Gases:	**$440 million**
Air Pollution:	**$150 million**
Total Savings	**$10.0 billion**

You Save: $959 per year

(Average annual savings for commuters using the bottleneck)

Washington, DC/Virginia

I-66 at the I-495 (Capital Beltway) Interchange



Summary

Washington area residents would reap nearly $5 billion in economic benefits if needed improvements at the I-66 and I-495 interchange were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $790 annually in time and fuel alone.

Bottleneck Description

I-66 is a major commuter route in the Washington, DC, area. West of the I-495 interchange, it includes an HOV lane in each direction; east of the interchange, the entire four-lane facility is HOV in the peak direction during the peak period of travel. Even with HOV implemented, traffic volumes are very high in the vicinity of the interchange.

Costs vs. Benefits

Virginia officials have identified this interchange as a priority for funding, but no specific improvements have been approved at this time, so identifying the project cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $220 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the I-66/I-495 interchange up to level of service D operations[11] would generate approximately $5.1 billion in economic benefits.

Personal Time Savings	**$2.8 billion**
Commercial Time Savings	**$1.2 billion**
Fuel Savings	**$430 million**
Safety Savings	**$400 million**
Environmental Savings	
Greenhouse Gases:	**$220 million**
Air Pollution:	**$95 million**
Total Savings	**$5.1 billion**

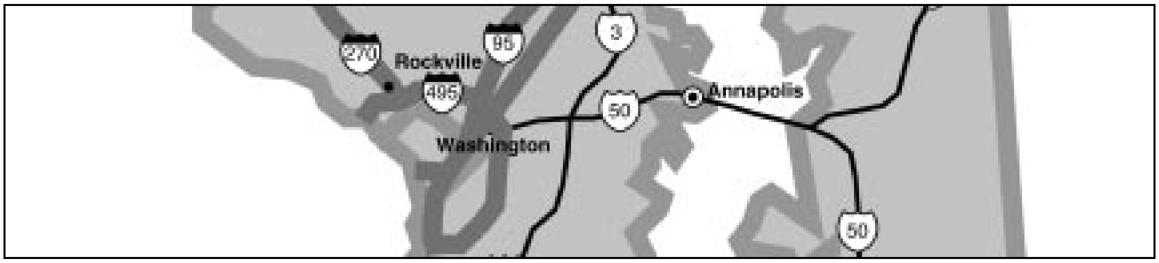
[11] See explanation of level of service D operations on page 4.

You Save: $790 per year

(Average annual savings for commuters using the bottleneck)

Washington, DC/Maryland

I-95 at the I-495 Interchange



Summary

Washington area residents would reap over $6 billion in economic benefits if needed improvements at the I-95 and I-495 interchange in Maryland were implemented. If traffic flow were improved, the average commuter traveling through this bottleneck twice each workday would save approximately $1,064 annually in time and fuel alone.

Bottleneck Description

I-95 meets the Capital Beltway (I-495) in Virginia and tracks with it eastward into Maryland. At a point roughly 180 degrees from where it entered the Beltway, I-95 veers off northward to Baltimore. The coincident section of I-95 and I-495 carries a high-volume mix of interstate and commuter traffic. At a point just before I-95 veers off northward, the total number of lanes on the coincident section is reduced from eight to five, leading to extensive congestion.

Costs vs. Benefits

No specific improvements have been designed at this interchange, so identifying the improvement cost is not possible. State and local officials, however, must weigh the cost of needed improvements against the benefits to be gained once a project is complete. In this case, the benefits to commuters, businesses, and the general public are estimated to be over $266 million annually.

The Economic Benefits of Improvements: 2000–2022

Allowing for a 3-year construction period and a 20-year project life, bringing the I-95/I-495 interchange up to level of service D operations[12] would generate more than $6 billion in economic benefits.

Personal Time Savings	**$3.4 billion**
Commercial Time Savings	**$1.4 billion**
Fuel Savings	**$520 million**
Safety Savings	**$410 million**
Environmental Savings	
Greenhouse Gases:	**$270 million**
Air Pollution:	**$130 million**
Total Savings	**$6.1 billion**

[12] See explanation of level of service D operations on page 4.

You Save: $1,064 per year

(Average annual savings for commuters using the bottleneck)

Chapter Two: The Opportunity Costs of Project Delays

The case studies presented in Chapter One consider the economic benefits of each highway improvement project as if the projects were to be started immediately. However, except for those projects that are already planned or under way, most of the improvement projects are years away from groundbreaking. Delays can result from a variety of factors, but lack of sufficient financial resources is often key. In addition, significant delays are built in to our current system of moving highway projects from the planning stages to implementation. No matter the cause, the analysis in this chapter indicates that the cost of delay is significant from an economic standpoint.

Chapter Two assesses the opportunity costs involved in delaying bottleneck improvements. The opportunity costs are measured in terms of wasted time and fuel, lost lives, additional injuries, and tailpipe emissions that could be avoided if the improvements were completed now rather than later. The economic benefits shown in Chapter One indicate the extraordinary value of projects to eliminate highway chokepoints. The analysis in this chapter is designed to convey the level of priority that public policy makers should place on those bottleneck improvements relative to competing demands for public funds and the cost of borrowing money to hasten the improvements.

The analysis begins by establishing the present value of each of the bottleneck improvements identified in Chapter One. Present value tells us how much a project is worth if we were to borrow money in order to finance it. A present value calculation takes into account the fact that economic benefits from a multiyear highway project are derived over time and *that deferral of benefits reduces the amount that beneficiaries are willing to pay for them.* Present value, in other words, tells us how much we should be willing to pay for a project right now, given the estimated economic benefits over the life of the project.

Next, as a measure of the impact of delays in project development, the opportunity costs of a three-year delay before construction begins for each of the bottlenecks are calculated in present value terms. The societal and economic benefits over the useful life of each project remain the same, but a three-year deferral creates opportunity losses that diminish the present value. For example, a three-year delay in the start of a major project is likely to lead to fatalities, injuries, and pollution which otherwise might have been prevented.

Finally, this chapter includes a brief discussion of the delays built in to the nation's current system of project development. As noted previously, there may be numerous reasons for delay in the development of a particular project—lack of sufficient financial resources frequently being a key factor—but government regulatory and administrative requirements often create significant, time-consuming hurdles. *Saving Time, Saving Money* provides a tool to measure the economic costs of those built-in delays.

Present Value

In order for bonds issued to finance a highway project to make economic sense, the benefits from the project must have a present value—at an appropriate discount rate—that exceeds the dollar amount of the bonds issued. The appropriate discount rate is assumed herein to be 7 percent in real terms, or approximately 10 percent at the currently prevailing inflation rate of 3 percent. The present values of the 17 principal projects and 149 other projects were calculated using this discount rate along with the annualized benefits in Table 1 and the estimated useful life of each project. The results are presented in the first numeric column of Table 2.

The present value criterion does not affect the tangible benefits from the projects, such as the time and fuel saved or accidents prevented, and uses the same valuation measures as the total benefits criterion. However, the present value criterion explicitly recognizes that deferral of benefits reduces the amount that beneficiaries are willing to pay for any given benefit. Hence, as shown by a comparison of Table 1 and Table 2, the present value of benefits from each project is less than the cumulative benefits over the project's useful life.

Whereas the cumulative benefits of all 166 projects were $336 billion, the present value of these benefits is $164 billion, of which $62 billion is attributable to the principal 17 projects.

The second column of Table 2 contains the present value of each project, assuming the start of the project is delayed for three years. The revaluation with a three-year delay maintains the rank order of the improvement projects but significantly reduces project values. Aggregated over all projects, a three-year delay sacrifices over $30 billion in present value, or approximately 18 percent. Hence, while it can be argued that the discount rates in this study are too large, thereby yielding unduly conservative estimates of present values, it would be untenable to claim that delay is innocuous or beneficial.

Table 2. Present Values of the Economic Benefits of Unclogging America's Worst Bottlenecks (2000$)

Project	Present Value	Present Value with Three-Year Delay	Benefits Foregone
I-495/I-270 (MD)	6,544,000,000	5,342,000,000	1,202,000,000
US-59/I-610 (TX)	5,178,000,000	4,227,000,000	951,000,000
I-40/I-25 (NM)	5,075,000,000	4,143,000,000	932,000,000
I-285/I-85 (GA)	4,806,000,000	3,923,000,000	883,000,000
SR-55/SR-22 (CA)	4,239,000,000	3,461,000,000	778,000,000
I-95/I-495 (VA)	4,227,000,000	3,451,000,000	776,000,000
I-285/I-75 (GA)	3,863,000,000	3,154,000,000	709,000,000
I-93, Central Artery (MA)	3,431,000,000	2,801,000,000	630,000,000
I-610/I-10 (TX)	3,424,000,000	2,795,000,000	629,000,000
US-101/I-405 (CA)	3,176,000,000	2,592,000,000	584,000,000
I-95/I-495 (MD)	3,008,000,000	2,456,000,000	552,000,000
I-75/I-85 (GA)	2,935,000,000	2,396,000,000	539,000,000
I-10/I-5 (CA)	2,830,000,000	2,310,000,000	520,000,000
I-405/I-10 (CA)	2,749,000,000	2,244,000,000	505,000,000
I-66/I-495 (VA)	2,526,000,000	2,062,000,000	464,000,000
I-290/I-88/I-294 (IL)	2,124,000,000	1,734,000,000	390,000,000
I-25/I-225 (CO)	1,979,000,000	1,615,000,000	364,000,000
Subtotal: 17 Worst Bottlenecks	62,115,000,000	50,704,000,000	11,411,000,000
All 166 Bottlenecks	164,503,000,000	134,284,000,000	30,219,000,000

Note: Detail may not add to total because of rounding.

Sources: *Unclogging America's Arteries;* data provided by Cambridge Systematics, Inc.; and author's calculations.

Regulatory and Administrative Bottlenecks

Under current law, the planning and project development process for federally aided transportation projects commonly takes eight years, whereas most construction is completed within one to five years. Edward V.A. Kussy, Deputy Chief Counsel of the Federal Highway Administration, has described the labyrinth of modern administrative law in his 1996 Transportation Research Board Distinguished Lecture.[1] Essentially, federal highway grants have been made subject to a host of requirements whose purposes represent multiple social goals. Consequently, the seemingly straightforward process of rebuilding dilapidated highways has become encumbered by administrative requirements intended to protect bystanders and nonusers, to the point that necessary highway improvements often are delayed indefinitely.

V. Kerry Smith, University Distinguished Professor in the Department of Agricultural and Resource Economics at North Carolina State University, has been examining this issue. In a recent article with two colleagues, he reports the results of a statistical analysis of parts of the highway review process.[2] Smith finds that federal environmental regulations have a statistically significant impact on construction costs, in large part because the regulations cause deferrals of construction activity. Essentially, federal regulations significantly increase the costs of building roads. A striking finding was that Section 404 permits (under the 1972 Clean Water Act) commonly resulted in a delay of 215 days, or more than half a year. This finding does not suggest that such delays are additive across the dozens of individual regulations and permits. It does indicate that administrative law causes substantial expenditure of highway tax funds for work that reduces government's responsiveness to evidence of wasted time, wasted fuel, unnecessary crashes, and preventable pollution.

As an example of this phenomenon; the latest major news in the lengthy saga of the Woodrow Wilson Memorial Bridge reconstruction project was approval by one court in December 1999 of plans that had been called into question by a lower court in April 1999. Those plans has been in development for years, owing to the lengthy administrative process established in federal law. They were held up once more through litigation in which petitioners alleged, and the lower court agreed, that the multiyear planning process for this project had not been sufficiently thorough.

Progress measured in one approval at a time has been the story of this reconstruction project, whose supporters optimistically believe that work may begin in the year 2000. If they are right, the bridge will be reconstructed by 2007, just in time to forestall a ban of truck traffic on this section of one of the nation's most heavily traveled Interstate highways.

The current bridge, built in 1961 and located just south of Washington, DC, creates a bottleneck that in turn causes a one-mile backup, on average, on I-495 during the best weekday travel, six miles on the worst days. If the reconstruction schedule had been set to accommodate users of the bridge, reconstruction would have taken place years—perhaps decades—ago. The accident rate on the bridge is double the rate elsewhere on I-495, itself a route with more accidents than many interstates have. In addition, emergency vehicles often have trouble reaching accident sites because the traffic is so congested.

The Woodrow Wilson Memorial Bridge is just one example of a desperately needed improvement at a significant highway bottleneck where delays attributable to the regulatory and administrative review processes have increased the construction and opportunity costs associated with the project. It appears that detailed re-examination of administrative law requirements affecting highway projects may be necessary, important, and urgent.

[1] Kussy, Edward V.A., "Surface Transportation and Administrative Law: Growing Up Together in the 20th Century," *Transportation Research Record*, No. 1527, Washington, DC, Transportation Research Board, 1996.

[2] Smith, V. Kerry, "Do Environmental Regulations Increase Construction Costs for Federal-Aid Highways? A Statistical Experiment," *Journal of Transportation and Statistics*, May 1999, Washington, DC, U.S. DOT/BTS, pp. 45-59.

Conclusions

- The benefits of improvements to major highway interchanges far exceed the costs of those improvements, in the vast majority of cases. Over their 20- to 30-year lifetimes, improvements to the top 17 bottlenecks and 149 other major chokepoints reviewed in this study exhibit enormous benefits, on the order of $336 billion in year 2000 dollars. The project life benefits swamp the estimated construction costs in nearly every case for which specific cost data were available.
- The finding of benefits that are very large in relation to costs is based on conservative economic assumptions about the value of benefits. For example, the reconstruction of the I-40/I-25 Interchange in the Albuquerque, New Mexico, area is estimated to take two years and cost $210 million. By contrast, the benefits are estimated in this study as more than $10 billion over a 22-year construction and useful life period. Approximately one-half of the $10 billion in benefits accrue in the form of time savings to commuters and other individual travelers. However, the estimated time-saving benefits assume a value of time of only $6 per hour for each traveler, a personal time value that is one-half the value used by the Texas Transportation Institute and that roughly amounts to the national minimum wage. Finally, the benefits estimated in this study take no account of the time, fuel, and safety gains realized by travelers diverted away from inferior roads because of the improvements studied, and no attempt was made to assess gains to landowners, employers and employees, or state and local governments.
- Almost one-fourth of the total benefits represent operating cost and time savings for commercial traffic—from surgeons traveling between hospitals and plumbers between jobs to express delivery vans and heavy trucks. These benefits also are conservatively estimated because they take no account of projected growth in commerce and trade. For example, the *Economic Report of the President*[3] observes that the growing role of Canada and Mexico as America's trading partners has been accompanied by growth in the value of traffic shipped by land. Inasmuch as many of the major highway projects for which benefits were estimated are arteries of commerce and trade, their benefits to commercial travelers are reasonably—but only conservatively—represented in this report because commercial traffic is assumed to account for only 5 percent of total traffic.
- Borrowing may be a highly desirable financing option for many of the top 17 bottlenecks and 149 other major chokepoints assessed herein. The present values of the estimated benefits are very high, amounting to almost $164 billion for the 166 projects at an opportunity cost of capital of 7 percent in real terms, roughly an interest rate of 10 percent in year 2000. Even assuming an opportunity cost of capital of 10 percent in real terms, the present values of the 17 major projects are almost $49 billion, and the present values of all 166 projects total about $130 billion. These high present values suggest that debt financing of the projects could be easily justified.
- Besides time savings to individuals and cost savings for commercial travelers, roughly one-fourth of the economic benefits estimated are more or less evenly divided among fuel savings, safety gains, and enhanced environmental quality. Hence, ameliorating traffic congestion at the worst

[3] Government Printing Office, Washington, DC. February 2000, p. 209.

highway clogs—typically interchanges of urban interstates—will raise economic efficiency and enhance the quality of life. Therefore, there is much more at stake in unclogging America's worst bottlenecks than simply getting motorists to their destinations more quickly.

- Review of the administrative practices governing highway projects appears necessary, important, and urgent. Under current law, the planning and development process for federally aided highway projects commonly takes longer than actual construction, sometimes much longer. The resulting delays in meeting demonstrated demand for road improvements lead to deferral of benefits which add to large opportunity costs. For the 166 projects reviewed in this study, a three-year delay reduces the present value of benefits from $164 billion to $134 billion, an opportunity loss of about $30 billion.

Appendix A: Methodology

The methodology used in this report builds on the baseline work as reported in *Unclogging America's Arteries*. A review of the key assumptions from the baseline study is provided below, followed by the specific methodology used in this report.

The benefits of road improvements are (1) those realized by otherwise existing users, (2) those realized by users induced to travel by the improvements themselves, and (3) those realized by nonusers. In recent years, policy discussions have been limited to the deficiencies of America's overused road capacity and the unwelcome by-products of that overuse. Hence, recent policy discussion of proposed road projects has ignored benefit/cost criteria in economics and highway engineering textbooks, and instead concentrated on prospective impacts on traffic congestion, motor vehicle accidents, and air quality.[1] Like the *1999 Annual Mobility Report* of the Texas Transportation Institute, *Unclogging America's Arteries: Prescriptions for Healthier Highways*, prepared by Cambridge Systematics, Inc., for the American Highway Users Alliance (AHUA), is a response to the recent emphasis on traffic congestion and its consequences. *Unclogging America's Arteries* concentrated on measuring benefits realized by existing road users and partially measured benefits realized by nonusers, omitting consideration of benefits realized by users induced to travel because of the improvements. The decision to omit consideration of benefits accruing to induced travelers was based primarily on data constraints. Thus, the baseline study did not tabulate economic gains realized by drivers who would save time by switching routes, landowners who would reap windfalls, workers who would find new and better jobs, and firms that would relocate to take advantage of better transportation facilities. Also excluded from consideration were most of the new tax revenues that would be realized by governments. Most important, consistent with its methodology of not examining toll facilities, the AHUA study did not attempt to measure consumers' willingness to pay, which usually far exceeds costs and expenditures.

Hence, the study aimed to tabulate only those benefits that would result from improvements to existing deficiencies in the U.S. road system. Thus, the positive impacts measured by Cambridge Systematics are a very conservative representation of the likely benefits of the road improvements analyzed.[2]

In the first category (benefits realized by otherwise existing users), the study measured time saved, fuel conserved, and accidents prevented in respect to traffic volumes projected without improvements. In the third category, the study measured the reductions in pollution realized from smoother traffic flows.

Impacts of Improvement Projects

Unclogging America's Arteries compared two scenarios for each site: one in which no action was taken, and another with an actual or hypothetical improvement project. Traffic growth was assumed to be the same under both scenarios. However, in cases of rapid growth, a cap was placed on the ratio of traffic to capacity for the "no-improvement" scenario, and growth rates were not allowed to exceed 3 percent per year. Furthermore, delays were calculated for recurring congestion only, even though the sites also suffer from incident delays, and such delays tend to be aggravated by lack of periodic improvements.

[1] Wright, Paul H., *Highway Engineering*, sixth edition, 1996, chapter 4; and Garber, Nicholas J., and Hoel, Lester A., *Traffic and Highway Engineering*, second edition, 1997, chapter 13. References for discussion of benefit/cost criteria.

[2] For further discussion, see Hogarty, Thomas F., "The Untold Benefits of Roads and Travel," *Consumers' Research*, July 1999, pp. 10–14.

Because of data limitations, the report did not consider suppression of traffic growth by severe congestion in the "no-improvement" scenario, nor—as noted above—induced travel in the "improvement" scenario. In addition, impacts were estimated for each site—or group of sites—and aggregated, but no attempt was made to model system-level effects.

The report computed net impacts; that is, it calculated impacts for the reconstruction period, during which it was assumed highway capacity was reduced by 20 percent, and a 20-year service life. The assumption of a 20-year service life was very conservative. Highways—and improvements to highways—often have service lives lasting many decades. As one example, the Pennsylvania Turnpike is more than 60 years old and going strong. A more recent example is the Springfield (Virginia) Interchange, at I-95 and I-495, whose service life began in 1964 and lasted until 1999 without major improvements. Finally, the U.S. Department of Commerce, Bureau of Economic Analysis recently changed its depreciation practice in national income accounting to recognize the exceptional longevity of infrastructure such as major buildings and highways.[3] The new accounting practice confirms the everyday evidence that big buildings and major highways have service lives of many decades, and sometimes a few centuries. By assuming a 20-year life for improvements, therefore, the Cambridge Systematics analysis understated significantly the prospective physical benefits.

Peak periods were 7 to 10 A.M. and 4 to 7 P.M., and delays were reported for the entire six-hour period. To illustrate, a peak period delay of 10 minutes means that each vehicle traveling through the bottleneck experiences 10 minutes of delay. It was further assumed that each vehicle went through the bottleneck twice per day, but—consistent with its conservative approach—each vehicle was construed as single-occupant, versus the customary assumption of 1.2 occupants per vehicle.

[3] American Petroleum Institute, *The Benefits of Road Travel and Transport*, Research Study #089, January 1998, Appendix.

The number of crashes was estimated with a relationship that predicts accident rate as a function of average annual daily traffic and capacity. This relationship was prepared by Cambridge Systematics for the Federal Highway Administration (FHWA). Fatalities were estimated by applying a factor of 0.004 fatalities per crash, and injuries were estimated by applying a factor of 0.491 injuries per crash.

Fuel consumption was estimated from a FHWA relationship between fuel economy and delay, and these fuel economy estimates were used to calculate emissions of carbon dioxide (a nonpolluting gas which could lead to global warming) at a rate of 19.5 pounds of carbon dioxide per gallon of fuel consumed.[4] Emissions of pollutants were estimated from a model prepared for the FHWA Highway Performance Monitoring System.

Methodology Used in *Saving Time, Saving Money: The Economics of Unclogging America's Worst Bottlenecks*

The methodology used in this report takes many of the assumptions used in *Unclogging America's Arteries* to build specific economic benefits for each of the 17 case studies as well as the remaining 149 bottlenecks nationwide.

Monetary Measures

The underlying monetary measures in this report are estimates in year 2000 dollars (2000$) derived from review of similar estimates in previous studies. They were chosen on a criterion of reasonableness, with a bias to conservatism. The underlying monetary measures used comprise the following:

- The value of time for personal travel
- The value of time for commercial travel/transport
- The price of motor fuel
- The average cost of crashes, including implied values of life and limb
- The benefits of reduced air emissions implied in government regulations/proposals

[4] Transportation Research Board, *Toward A Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology*, 1997. Source for deriving the rate of carbon dioxide emissions relative to fuel consumption.

Specific assumptions associated with the monetary measures are discussed in turn in the following sections.

Value of Time for Personal Travel

Personal travel during peak periods has a subjective value that varies according to individuals' willingness to pay. The Texas Transportation Institute values time lost because of congestion at approximately $12 per hour, roughly double the minimum wage and modestly less than the average wage of "blue-collar" workers. When asked how much they value their time, individuals would be expected to refer to their wages because that is what they are paid for their time at work. However, an individual working full time typically works according to the employer's schedule, incurs work expenses, and pays taxes. Hence, "take home pay"—gross income minus expenses incurred and averaged over work plus commuting time—usually is much less than gross wages. Furthermore, few employees can fine-tune hours worked.

Economists who have studied this issue gauge the value of time lost in traffic as much less than $12 per hour. The valuation difference arises from methodological differences. In the view of economists, commuters' value of time is revealed, not by what they say but rather by what they do. In turn, what they do may be assessed from their transportation choices. If some commuters carpool rather than drive alone or take buses rather than taxis, economists reason that the commuters value their lost time less than the savings from electing a cheaper mode. Similarly, motorists who avoid a toll road by traveling longer on a toll-free road are said to be unwilling to pay the toll amount for the savings in time. A major study by the Brookings Institution found that the value of personal travel time during peak periods may be only $1–2 per hour for commutes of a mile or less, $4–7 per hour for commutes of 1–10 miles, and $8–9 per hour for commutes of 11–25 miles.[5]

One ongoing experiment in willingness-to-pay to save time is provided by the Dulles Greenway, a 14-mile private toll road connecting Leesburg, Virginia, and Dulles Airport. Compared with toll-free Routes 7 and 28, each with traffic lights, the Greenway saves travelers about 15 minutes for the 14-mile trip. Since the toll is $1.50 per trip, the toll implies a value of $0.10 per minute, or $6 per hour.

For purposes of estimating the benefits of reduced travel delays, this study uses $6 per hour as the value of time spent in personal travel. By contrast, the value of time for commercial vehicles is assumed to be $48 per hour. The $48 per hour estimate results from assuming nonfuel operating costs of $2.40 per mile and an average speed of 20 miles per hour in the following identity:

($/hour) = (miles/hour) * ($/mile),
or $48 = (20) * ($2.40).

(Fuel costs and savings for both commercial and personal vehicle traffic are computed separately.)

In its 1998 study, Appendix C, the Texas Transportation Institute valued time spent in personal travel at $11.70 per hour and assessed the operating cost of commercial travel as $2.55 per mile. In that appendix, the Institute assumed that 5 percent of travel during peak periods was commercial, an assumption also used in this study. In this study the fuel savings pertinent to commercial traffic are assumed to be roughly $0.25 per mile, making the total operating costs of commercial traffic $2.65 per mile, approximately the equivalent of the Texas Institute $2.55 per mile, but in year 2000 dollars.

Value of Fuel Saved

The relevant price for fuel is a share-weighted average of gasoline and diesel fuel prices, including taxes, expected to prevail over the next two decades, and expressed in year 2000 dollars. Given the impossibility of long-term fuel price forecasting, this study values fuel at an average pump price of $1.40 per gallon, consisting of $0.97 average price of fuel and $0.43 in federal/state/local excise taxes. For reference, as of March 6, 2000, the U.S. Department of Energy reported that the U.S. average price of gasoline was $1.54 per gallon. Prices

[5] Winston, C., and Shirley, C., *Alternate Route: Toward Efficient Urban Transportation*, Brookings Institution, Washington, DC, 1998, pp. 42–43.

were widely expected to rise during the spring and summer, but the Department's short-term energy outlook had projected prices falling in late 2000. Such a rise and fall would mirror approximately the course of gasoline prices during the 1990–91 Persian Gulf crisis and war. However, growth in the world economy could result in increasing crude oil prices in future years. In addition, even if the 1981–98 downward trend in U.S. gasoline prices were to resume, it is possible that fuel taxes will rise in real terms, given the backlog of transportation projects. In these circumstances, $1.40 per gallon in year 2000 dollars may be a conservative estimate of fuel over the next two decades.

Value of Accidents Forestalled

This study derives its estimates of crash costs mainly from the FHWA's *1997 Federal Highway Cost Allocation Study*, which presented crash cost estimates for the year 2000.[6] The estimate of crashes used herein—$95,000 per crash—implies valuations of fatal crashes at $4,850,000 each and injurious crashes at $150,000 each. These valuations lie between the upper and middle valuations used in the FHWA study.

The costs of motor vehicle accidents are difficult to estimate because they entail valuation of life and limb, and because responsibility for these costs is dispersed. Valuation of statistical lives and limbs has resulted from society's actions, ranging from awards to victims to actions by regulatory agencies, such as the Occupational Health and Safety Administration.

Valuation of Lives and Limbs

General Motors recently was ordered to pay $4.9 billion to six people who were burned when their 1979 Chevrolet Malibu exploded after its fuel tank was ruptured in a rear-end crash.[7] This extreme example illustrates how highly life and limb may be valued in extraordinary circumstances, but even average valuations are high. A review of survey, actuarial, and regulatory analyses found valuations of life ranging from $0.8 million to $6.4 million when expressed in 1988 dollars.[8] In its 1997 Federal Highway Cost Allocation Study, the FHWA used values of life ranging from $1 million to $7 million, expressed in 1994 dollars.

Cost Responsibility

Much of the responsibility for loss of life and limb is borne by individuals, who annually spend roughly $100 billion for private passenger automobile insurance. However, a study distributed by the National Highway Traffic Safety Administration[9] estimated that injuries sustained in motor vehicle crashes cost employers more than $50 billion annually. Finally, costs to federal, state, and local governments from motor vehicle crashes are known to be large, albeit not easily quantified.

Value of Greenhouse Gas Reductions

Global warming is a potential problem whose solution may require large reductions in fossil fuel use. Coal and petroleum have been targeted for possible reduction because burning produces carbon dioxide, which may cause or aggravate a warming of the Earth's climate. Hence, reductions in carbon dioxide emissions that would result from eliminating traffic delays would provide insurance against the need to restrict driving in the future.

In two steps, *Unclogging America's Arteries* estimated the impact on carbon dioxide emissions of improvements at the 166 sites. In the first step, the fuel savings from reductions in delay were calculated, and, in the second, the conventional multiplier of 19.5 pounds carbon dioxide per gallon of fuel was applied.[10] Over the lifetime of the 166 projects, emissions of carbon dioxide would be reduced by more than 223 million tons.

[6] Federal Highway Administration, *1997 Federal Highway Cost Allocation Study*, August 1997, pp. III-19.

[7] *Wall Street Journal*, July 12, 1999.

[8] Visccusi, W. Kip, et al., *Economics of Regulation and Antitrust*, 1995, p. 697.

[9] *What Do Traffic Crashes Cost?*, Washington, DC, National Highway Traffic Safety Administration, 1995.

[10] Transportation Research Board, *Toward A Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology*, 1997. Source for deriving the rate of carbon dioxide emissions relative to fuel consumption.

The appropriate valuation of these tons of carbon dioxide is "the carbon price," which the U.S. Department of Energy defines as follows:

> [T]he carbon price[s] represent the marginal cost of reducing carbon emissions to the [Treaty] specified level, reflecting the price the United States would be willing to pay in order to purchase carbon permits from other countries or to induce carbon reductions in other countries.[11]

Estimates of this carbon price have varied enormously, from as little as $4 per ton to as much as $400 per ton, mainly because of uncertainty about how much trading among nations would occur and how much reduction would be attempted. This study assumes a carbon price of $75, approximately the median price expected to prevail in the near future under trading among developed countries participating in the Kyoto treaty, as estimated at Yale University.[12]

Value of Improved Air Quality

Unclogging America's Arteries estimated changes in emissions of three major air pollutants: carbon monoxide, nitrogen oxides, and volatile organic compounds that would result from the 166 site improvements.

Improvements in air quality may be valued at damages avoided, which conceptually involves calculating emissions prevented, the impacts of those emissions on ambient air quality, exposure of people and property, physical consequences of exposure, and ultimately, dollar damages. As a practical matter, regulatory agencies often use default values, which are presumptive values assigned to pollutant emissions in the absence of specific data. For example, the Nevada Public Service Commission in 1991 valued carbon monoxide emissions at $0.46 per pound, nitrogen oxides emissions at $3.40 per pound, and volatile organic compounds at $0.59 per pound.[13] A survey of estimates used by regulatory agencies in California, Massachusetts, and New York found wide variation in valuations attached to each pollutant, with a presumption of substantially higher values in California.[14] For example, nitrogen oxides were valued at $0.89 per pound in New York, $3.25 in Massachusetts, and $6.28 in California.

A 1991 study jointly done by the Alliance to Save Energy and other groups, entitled *America's Energy Choices: Investing in a Strong Economy and a Clean Environment*, estimated air pollution values in 1990 dollars as follows: $0.45 per pound for carbon monoxide, $3.40 per pound for nitrogen oxides, and $2.77 per pound for volatile organic compounds. These and associated estimates were found in the American Petroleum Institute study to imply air pollution costs amounting to as much as $0.34 per gallon of gasoline.

By contrast, the Brookings Institution study cited above[15] reported more recent estimates for Los Angeles of approximately 3 cents per gallon for automobiles, and assumed the higher pollution costs from buses to be only 6 cents per mile. These more recent estimates imply that the valuations usually applied to air pollutants are lower than had been presumed. However, the presumption of relatively high valuations for California appears to be correct. Indeed, for many areas with good air quality, the value of further reductions in pollutants such as carbon monoxide and volatile organic compounds may be very small. This study values carbon monoxide at $0.25 per pound, nitrogen oxides at $1.50 per pound, and volatile organic compounds at $0.50 per pound for all 166 sites except four major sites in Los Angeles, where these values are tripled.

Table A1 summarizes key monetary values used in this study, and cites values used in some other studies.

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[11] Summary of the Kyoto Report, 1998 (published online at www.eia.doe.gov/oiaf/kyoto/cost.html).

[12] Nordhaus, W. and Boyer, J. "Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol," *Energy Journal*, Kyoto Special Issue, 1999.

[13] National Economic Research Associates, *External Costs of Electric Utility Resource Selection in Nevada*, Final Report Prepared for Nevada Power Company, March 1993.

[14] American Petroleum Institute, "Energy Prices and Externalities," Research Study #069, May 1993, pp. 14–17.

[15] Winston, C. and Shirley, C. *Alternate Route: Toward Efficient Urban Transportation*, Brookings Institution, Washington, DC, 1998, pp. 42–43.

Table A1. Summary of Estimated Monetary Values for Key Variables

Variable	Value in This Study	Value in Reference Study
Personal Time	$6/hour	$12/hour (Texas Transportation Institute)
Commercial Cost	$2.65/mile	$2.55/mile (Texas Transportation Institute)
Fuel Cost	$1.40/gallon	$1.54/gallon/gasoline/(3/6/00) (U.S. Department of Energy)
Value of Life	$4,850,000	$1–7 million (U.S. FHWA)
Carbon Price	$75/ton	$4–400 (U.S. government agencies)

Average Annual Savings per Commuter

This value represents annual savings of time and fuel averaged over personal and commercial vehicles, assuming that each project has a service life of 20 years and that each vehicle contains no passengers and passes through the bottleneck twice daily.

Appendix B: Sensitivity Analysis

The present value criterion is sensitive to the choice of discount rate. Some governments may reason that their fiscal policy should be conservative, borrowing funds for only those projects that have a substantial present value at a high discount rate. The judgment herein is that the highest discount rate that makes sense is 10 percent in real terms, or approximately 13 percent at today's inflation rate.

All the estimates in this study are sensitive to the value assumed for time spent in personal travel. As discussed earlier, the value used herein is $6 per hour, or approximately one-half the value assumed by the Texas Transportation Institute in its analyses. Hence, it also is useful to know what the estimates of improvement project benefits would be if personal travel time had been valued at $12 per hour.

Table B1 illustrates present values for each improvement project based on a discount rate of 10 percent. It also shows cumulative, project-life benefits assuming the value of personal travel to be $12 per hour.

Comparing the two columns of present values in Table 2 with the column of present values in Table B1 reveals that a discount rate of 10 percent reduces the present values of each project by slightly more than the impact on values of a three-year delay. For example, the 17 major projects have a total present value of about $62 billion if the discount rate assumed is 7 percent. A 10 percent discount rate reduces this $62 billion to less than $49 billion, while a three-year delay reduces the $62 billion to less than $51 billion. Thus, for these projects, a three-year delay is almost as bad as a 3 percentage point increase in the cost of capital.

Comparing project life benefits in Table 1 with project life benefits in Table B1 shows that a higher value of personal time makes a remarkable difference. With personal time valued at $6 per hour, the lifetime benefits of 166 projects are $336 billion. If personal travel time is valued at $12 per hour, then project lifetime benefits increase to $518 billion, a jump of more than 50 percent.

Neither project benefits nor present values would be as sensitive to changes in other assumptions. Therefore, the crucial questions in this study are the valuation of personal time and the choice of an appropriate discount rate, or opportunity cost of capital.

Table B1. Sensitivity Test Values: 1) Present Value at 10% Discount Rate and 2) Project Benefits at $12/hour Value of Personal Travel (2000$)

Project	Present Value at 10%	Project Benefits at $12/hour
I-40/I-25 (NM)	4,025,000,000	15,791,000,000
I-25/I-225 (CO)	1,517,000,000	7,012,000,000
I-93, Central Artery (MA)	2,688,000,000	11,184,000,000
I-405/I-10 (CA)	2,180,000,000	8,302,000,000
SR-55/SR-22 (CA)	3,341,000,000	13,236,000,000
US-101/I-405 (CA)	2,503,000,000	9,872,000,000
I-10/I-5 (CA)	2,230,000,000	8,793,000,000
I-75/I-85 (GA)	2,313,000,000	9,251,000,000
I-285/I-85 (GA)	3,787,000,000	15,207,000,000
I-285/I-75 (GA)	3,044,000,000	12,213,000,000
I-290/I-88/I-294 (IL)	1,684,000,000	6,576,000,000
I-495/I-270 (MD)	5,157,000,000	20,760,000,000
I-95/I-495 (MD)	2,371,000,000	9,526,000,000
US-59/I-610 (TX)	4,081,000,000	16,386,000,000
I-610/I-10 (TX)	2,698,000,000	10,798,000,000
I-95/I-495 (VA)	3,226,000,000	15,577,000,000
I-66/I-495 (VA)	1,990,000,000	7,971,000,000
Subtotal: 17 Worst Bottlenecks	48,836,000,000	198,453,000,000
All 166 Bottlenecks	129,639,000,000	518,457,000,000

Note: Detail may not add to total because of rounding.

Sources: *Unclogging America's Arteries;* data provided by Cambridge Systematics, Inc.; and author's calculations.