Congestion Mitigation

Programs and Strategies

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ABSTRACT

Highway congestion impacts society, freight, and the environment. Several programs are being implemented and supported by the Federal Government to fight congestion. Congestion mitigation strategies and tactics continue to develop as research continues to introduce new ideas and concepts.

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INTRODUCTION

The traffic congestion crisis remains one of the nation's largest transportation issues. Traffic congestion can be reoccurring or a one time event transpiring from a number of events such as bottlenecks, traffic incident, work zones, bad weather, special events, or at interchanges and intersections due to poor signal timing. Figure 1 illustrates the percentage of each congestion source in the nation. Congestion on our highway system has an effect on people, the environment, and our resources. The effects of congestion have grown from urban areas to also altering driving conditions in rural areas. Many efforts are being made to reduce and solve the overcrowding of the nation's highway system. The federal government has recognized the problem and is working diligently with agencies to introduce more programs and funding. The United States Secretary of Transportation, Mary Peters commented on the congestion issue at the 86th Annual Meeting of the Transportation Research Board. She said, "Today, congestion is choking our cities, clogging our highways and airways, and complicating our lives. Real world examples are endless, painting a telling picture of how gridlock is taxing our economy and our environment" (2). While there are many solutions and design options to reduce congestion, many constraints limit the alternatives. Traffic congestion continues to grow and plague urban and rural areas across the nation.

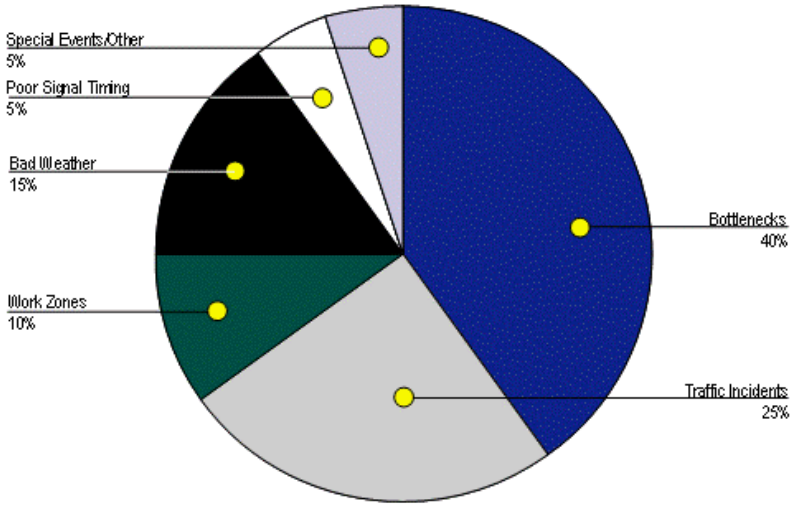

FIGURE 1: Sources of Congestion **Source: 1**

Definition

Traffic congestion can be expressed in many ways and under several conditions. Highway congestion occurs when the traffic demand approaches or surpasses the available capacity. With traffic demands and capacities constantly changing, congestion can vary from day to day (3). Measurements of the level of service, speed, travel time, and delay are often used to express the severity of congestion. Reliability of the highway system is most often accepted measure of the society. The predicted travel time should be reliable, knowing that a trip takes a specific amount of time each day without a large variance of time from day to day (4). About half of congestion is recurring every day in the same location. Many urban areas spend approximately 32% of daily travel time in congestion.

Congestion can also be nonrecurring resulting from traffic incidents, work zones, or weather conditions (3). Each state collects highway data for its system, the Federal Highway Administration (FHWA) is looking into ways to establish uniformity in the data with road sensors and other technology. The FHWA is also developing additional measures to include travel time, reliability, and other aspects of congestion to be included the data collection (3). Uniformity and standard elements of data will allow agencies to identify areas of concern with the ability compare the common elements. Traffic congestion is hard to define precisely, as it represents the difference between what the users of the highway system expect and how the system is performing.

EFFECTS OF HIGHWAY CONGESTION

Traffic congestion not only has an effect on society, but it also causes harm to the environment and puts restrictions on our nation's freight. People spend several hours and dollars every day on their commute to and from home. The congestion of the highway system also leads to increase costs in freight due to the extra time and energy that is needed. The extra time creates a need for extra fuel, which is an additional cost to the users and contributes to the pollution of the environment.

Society

People that choose to use their personal automobile accept the fact that extra costs are associated with every day travel. Instead of having to schedule for public transit or accompany another person's schedule to carpool, many Americans pay the extra costs related with the freedom of their own vehicle. The extra time spent in the congested highway system takes valuable time away from people that could be spent at work or with their family. The Texas Transportation Institute (TTI) conducted a study on traffic congestion in 85 urban areas, the results indicated that the overcrowding of the highway system lead to 3.7 billion hours of delay or 43 hours per person per year (5). The outcome of the waste time and fuel was found to be $63 billion, which is $384 per person each year. "Unless we manage highway congestion, our nation will continue to incur economic costs in forgone productivity, wasted fuel, and a reduced quality of life" (3). It is evident that people have to pay extra costs for the freedom and ease of using their own automobile.

Freight

Congestion has an impact on international and domestic freight movement. Congestion on the highway and at the borders continues to put restrictions on the movement of goods through the nation. In their study for the FHWA, Cambridge Systematics found that highway system bottlenecks caused 243 million hours of delay annually.

These delays have resulted in a cost of $7.8 billion per year for the users in 2004 (6). Figure 2 below shows the location of interchange bottlenecks in the United States by the circled locations. These interchanges account for the majority of the truck hour delays. The delays are estimated at 124 million hours annually, directly costing the user $4 billion per year, which is carried over to the consumers buying the products (6). Freight movement by truck is expected to increase the vehicle miles traveled by 3 percent annually through 2020, while passenger cars increase by 2.5 percent (7). With the increase in freight and vehicle miles the nation will be forced to add lanes or look at other alternatives to increase the capacity of the highway system.

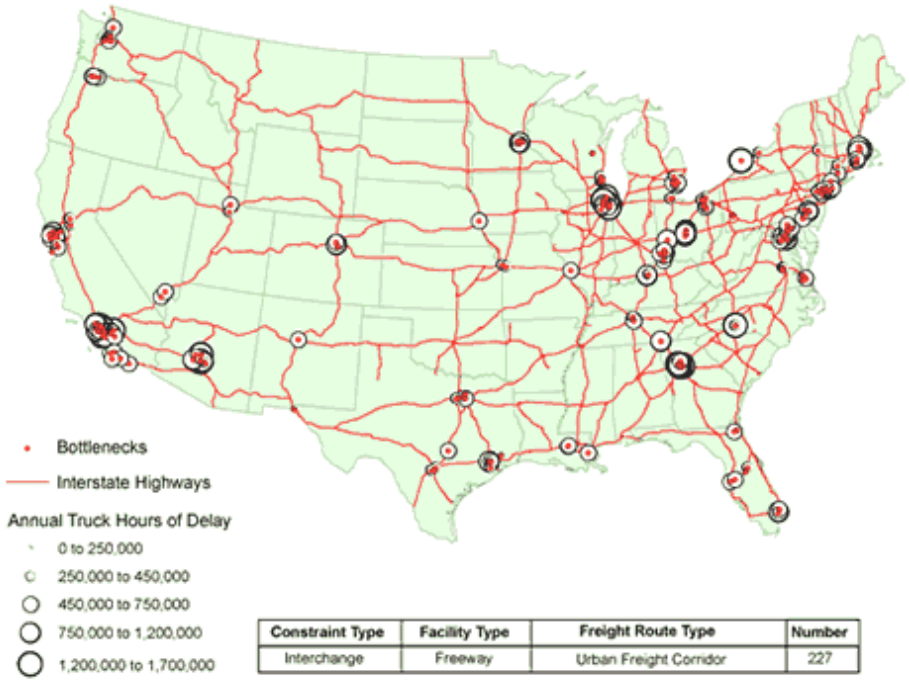

FIGURE 2: Interchange Capacity Bottlenecks Used as Truck Corridors **Source: 6**

Environment

As a result of traffic delays, additional fuel is burned and harmful gases are released into the air. Drivers spend many hours creeping along in overcrowded freeways burning excess fuel. Oil is a valuable, nonrenewable resource; although more efficient vehicles are being constructed and alternative fuels are being introduced, there is a need to reduce the amount of energy that is wasted because of a congested highway system. Burning fuel discharges

harmful gases such as nitrogen oxides, carbon monoxide, and hydrocarbons that continue to harm the environment. Reducing congestion would drastically reduce the amount of fuel used and decrease pollution of the environment.

SOLVING THE CONGESTION PROBLEM

The number of automobiles traveling on the nation's highway system is out weighing the capacity. There are a number of solutions and numerous dollars that have been spent on congestion mitigation. The federal government has also implemented a number of programs to address the issue. Many different design options are available, however they can be very costly. An intelligent transportation system contains many robust components that can successfully reduce congestion at a reasonable cost. Efforts have also been made to design and implement a rapid urban flexible system in urban areas. A new planning and traffic forecasting technique is also being explored to convince the public of the need to solve congestion using benefit/cost analysis. Congestion pricing has shown great benefits in London and is being tested in some of the nation's cities. Agencies continue to search for realistic solutions to this costly problem.

Government Efforts

The federal government has allocated a large budget into research and projects to reduce congestion. The government has also been very active in creating programs designed to solve congestion problems quickly and efficiently. The National Strategy to Reduce Congestion on America's Transportation Network plan was introduced in May 2006 by the US Department of Transportation, which is also part of the FHWA's high priority efforts to reduce congestion. The strategic plan, often referred to as the Congestion Initiative, provides six components to help federal, state, and local officials work together to reduce congestion (8). The six components include urban partnership agreements (UPAs), public private partnerships (PPPs), corridors of the future, reducing border congestion, reducing Southern California freight congestion, and increasing aviation capacity. The US DOT plans to select one to five UPAs from urban areas and will supply them with available resources and support. The US DOT is looking for a comprehensive plan to reduce congestion by including a congestion pricing demonstration, enhanced transit services, increased use of telecommuting and flex scheduling, and advanced technology deployments (8). The PPPs are designed to incorporate private investors into construction, ownership, and operation of transportation infrastructure. The Department is encouraging the formation PPPs by utilizing existing federal programs to reduce or remove barriers against private sector investing (8). The Department plans to select three to five "Corridors of the Future" in need of investment. The Corridors of the Future program is intended to accelerate

the development of new interstate highway and rail capacity that will result in multi-state and multi-use transportation corridors (8). The border congestion component will work to find and solve congestion problems resulting from travel and trade without sacrificing the safety or security of the borders. These four components of the strategic plan will increase the nation's efforts to reduce bottlenecks and delays on the highway system.

The Work Zone Mobility and Safety Program and Highways for Life are two more examples of the government's effort to reduce highway congestion. Work zones contribute to 10% of the nation's congestion problem as we saw earlier. The Work Zone Mobility and Safety Program addresses construction-related congestion by researching, developing, and promoting several construction strategies and guidelines. The program looks to develop national policies and guidance initiatives that concentrate on safety and congestion in work zones (9). Reducing construction duration and exposure focuses on tactics such as accelerated construction techniques, full closures, and night work that should help reduce bottlenecks in construction zones. The use of intelligent transportation systems (ITS), new construction methods, and incident management are example of some innovative project management strategies that the program supports. Communication and training are also emphasized in the program to share ideas or strategies that have been successful (9). "The purpose of Highways for LIFE (HfL) is to advance **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges" (10). The three main goals of the HfL program include improving safety during and after construction, reduce congestion during construction, and improve the quality of the highway infrastructure. The HfL emphasizes the need to adopt new innovations in the highway construction industry (10). One of the most important aspects of both programs is the need to communicate successful ideas and strategies to reduce congestion. These programs are just a couple of the more recent efforts to help reduce congestion.

Design Efforts and Strategies

Highway congestion can be reduced using various design options and strategies. The most obvious solution is to add capacity to the highway system by widening the roadway. In most urban areas the right of way is limited and very expensive; therefore, other options have to be considered. High occupancy vehicle lanes, ramp management, separate truck and automobile lanes are other design options and strategies available to reduce congestion. Restricted right of way is causing designers to think above and below ground with innovative designs of tunnels and "stacking" lanes. The Federal Government has already spent $340 billion on public transit to help reduce congestion. Public transit is used in 2% of the trips, it's evident that the problem needs to be solved on the

roadway as people are accustomed to the freedom of their automobile (11). These design options look to reduce the congestion problem on the roadway.

High occupancy vehicle (HOV) lanes provide special lanes for vehicles with two or more passengers. The lanes are specifically marked on the roadway for use by vehicles with multiple passengers only. The lanes are intended to get the larger number of people to their destination quicker than those that drive by themselves. However, problems occur with the lanes especially at interchanges. Significant planning of the lanes is needed to ensure that the lanes are not contributing to the congestion issue by creating spillback onto other routes. The interchange problems are caused by drivers that have to cross multiple lanes of traffic access the HOV lanes. On an average day fifteen million people carpool, while 84 million people drive alone (11). HOV lanes have not performed that well and do very little to relieve congestion. Many of the lanes are being converted to general purpose lanes, while others are turned into high occupancy toll (HOT) lanes. Drivers have to pay to drive in the HOT lanes, with prices fluctuating with the traffic volume. These HOT lanes apply the concept of value pricing which is defined as "a system of optional fees paid by drivers to gain access to alternative road facilities providing a superior level of service and offering time saving compared to the free facility" (12). The funds generated help support the cost of converting the lanes into HOT lanes and also contribute to the maintenance costs of the facility. HOT lanes are being implemented by several agencies across the country and also being introduced as public-private partnerships.

Ramp management is another approach used to help mitigate congestion. This technique uses control devices such as signs, traffic signals, or gates to control the number of vehicles entering or leaving the freeway. Ramp management is one of the most cost effective tools for improving operation and safety. Minneapolis implemented a ramp management system that has seen a benefit to cost ratio of over 15:1 and reduced emissions by 1160 tons per year (13). The strategy is also very versatile; it works well with other tactics such as HOV lanes and incident management techniques. As with any other strategy, if not designed and used properly it can have a negative impact on traffic flow. Ramp management can create spillback from ramps to adjacent freeways causing issues on other roadways (13). Ramp management requires sufficient planning to reduce congestion without shifting congestion to other roadways.

Designers and planners have also considered the option of separate truck and automobile lanes. Parkways built in the 1920s and 30s had controlled access to be used by automobiles only. However, this concept has been

ignored for the past fifty years because federal regulations forbid separate lanes (11). The National System of Interstate and Defense Highways was built to move heavy military equipment easily through the nation. Therefore, they were constructed for heavy truck loads and could handle automobiles easily. The separate lanes would be very beneficial in urban areas with five or more lanes. The inside lanes would be reserved for automobiles while trucks could be contained on the outside lanes. This could help the flow of traffic as the trucks have different acceleration rates, braking distance, and other characteristics that hinder the flow of traffic in urban areas (11). These lanes could be constructed using different standards to allow for heavy truck traffic on the outside lanes and small lanes with lighter weight standards on the inside lanes. In the United States, freight costs about $28 billion annually. If the lanes were constructed to allow larger trucks and some of the regulations were changed, the US could save 12 percent by allowing larger trucks that are currently being used in other countries (11). The separation of lanes is another strategy that could help reduce congestion in urban areas, but significant effort would have to be put into the design and planning to look at the movement on interchanges and techniques to enforce the separation.

Innovative design techniques encompassing tunnels and stacking vehicle lanes are growing in popularity with advances in construction techniques. Advances in tunnel technologies appear to be lowering the tunnel-building costs which should make them more common in the near future (11). The concept of separate lanes for cars and trucks could also be applied when designing tunnels and double-deck highways to allow for lower heights of clearance. Car only tunnels and decks could be constructed with ceilings as low as 7 feet and lanes that are 10 feet wide to lower the construction cost. This should help reduce traffic congestion with 80 percent of the nation's capacity of traffic being passenger vehicles (11). The restriction of right of way in urban areas has caused engineers and planners to explore design options above and below the ground.

Intelligent Transportation Systems

Many agencies are using intelligent transportation systems (ITS) to reduce traffic bottlenecks. The FHWA defines ITS as a system that uses electronics, communication, or information processing singly or together to improve the efficiency or safety of a transportation system (14). ITS helps reduce congestion by communicating with the users of the conditions that exist. The systems will help warn or inform drivers of conditions that exist on the roadway such as work zones, tolls, incidents, or the current level of service. ITS will help incorporate a incident or traffic management system that will communicate vital traffic information to the drivers. The issues may be an accident that has occurred and is blocking traffic or that a section of the freeway is at maximum capacity and drivers

should consider an alternate route are a couple of examples. Work zones were mentioned earlier and ITS plays a significant role in educating drivers through the work zone efficiently and safely to minimize confusion and congestion. Automated tolls are another ITS concept that allows traffic to move efficiently through a toll booth. Many highway bottlenecks occur at toll booths, this tactic scans or records information about the vehicle as it passes through instead of having to stop and wait for a gate. The information is stored and later charged to the driver by mailing a bill or paid by a pre-paid pass. The system is very efficient and also decreases the number of people needed to operate the toll booth. These are a few examples of how ITS is working to reduce congestion.

Rapid Urban Flexible (RUF) System

RUF transportation systems are flexible enough to cover most of the varied transportation needs. The system was developed by Palle Jensen in Denmark, where a prototype was also constructed. RUF dual mode is a system that allows vehicles to drive on a regular roadway or using a special guideway (15). As shown in Figure 3 the RUF vehicle is very compact and versatile. The special designed vehicles are manually controlled on the road and automatically controlled on the rail system. The rail system consists of a network of guideways connected in junctions. The junctions will allow the vehicles to enter and exit the rail system. When exiting the rail system the RUF runs a test to ensure that the operator is prepared to take over the vehicle on the roadway. If the driver is not ready or does not respond the system automatically pulls the vehicle over close to the egress ramp but away from traffic flow (15). The system will continue to try and wake the operator as they are being charged extra for the use of the facility. The rail system allows vehicles to travel at speeds up to 95 mph with little space between vehicles. The system eliminates the possibility of incidents contributing to the congestion issue as well as achieving a high level of capacity with vehicles closely spaced. The electric RUF transport vehicles can range in sizes from 10 passenger maxi-ruf to a 2 seat mini-ruf (15). The system is able to obtain a high level of safety because of several construction details. A special brake assembly in the vehicles is pressed against both sides of the monorail, the brake pressure is not limited by gravity making it readily available. RUF vehicles are closely coupled on the rail to eliminate collisions and the system will only operate with seated passengers (15). Rapid Urban Flexible transportation system plans are being designed for Los Angeles, CA and Seattle, WA.

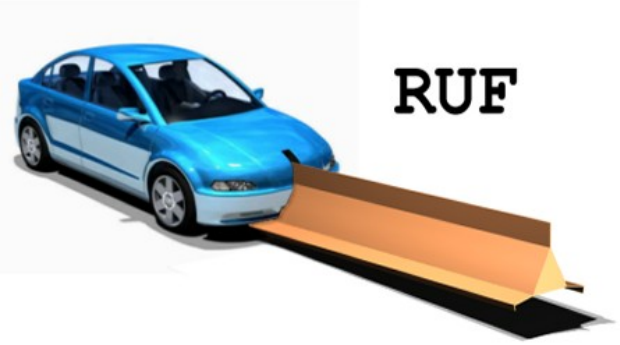

FIGURE 3: RUF Vehicle **Source: 15**

Planning and Forecasting Future Traffic

Traffic volumes, used to determine road capacity and design, are determined using extensive traffic forecasting and planning. Traditional traffic forecasting involves collecting data on the existing facility and throughout the region as well as calculating the expected growth in traffic for the region in general (16). The future traffic should reflect the regional plan for the region including expected economic, demographic, and land use trends compared to existing conditions. The calculated data can be entered into the region's travel demand model to simulate regional traffic flows and observe the behavior of the system (16). This is a general example of how future traffic volumes are determined with modifications to existing highway systems. Goal-oriented planning processes look to improve and expand on the traditional planning process. Major metropolitan areas in Texas and Georgia have developed a method to quantify the need for other projects and estimate the costs and benefits for the decisions (16). The goal of the Texas Metropolitan Mobility Plan (TMMP) is to eliminate serious congestion in the eight largest population centers. Costs were calculated using construction costs and decision-makers and public were provided information about the beneficial effect of additional transportation spending. This plan will provide a way to identify the progress and needs of the regions' traffic operations beyond the scheduled projects using the available funds (16). Congestion goals could also be included within the region goal to evaluate current systems and longer-term scenarios as well. The plan in Georgia, Atlanta's Aspirations Plan, was made up of a more detailed planning approach that included several factors including congestion relief. Projects whose costs were projected to be above the available funding were identified and selected using a prioritization process in the plan (16). The plan provided sufficient information to convince decision makers and the public of the need to increase the transportation budget. Both of the goal-oriented plans included consideration of a broad set of transportation and land use choices. The plans allowed the public to observe the range of project costs and how they affected the traffic congestion of the region. This new technique allows the public to easily see how the finances achieve the desired outcomes of the congestion relief strategies.

Congestion Pricing

Congestion pricing is another tactic used to reduce traffic congestion. Sometimes referred as value pricing, congestion pricing is a way of harnessing the power of the market to reduce traffic congestion. The strategy works to shift rush hour traffic of personal vehicles to other modes of transportation or to off-peak periods (17). Removing only a small portion of the rush hour traffic helps the efficiency of the traffic flow. The four main types of pricing

are variably priced lanes, variable tolls on entire roadways, cordon charges, and area wide charges (17). Variable pricing strategies and variable tolls were mentioned before by the use of HOT lanes. Cordon charges include variable or fixed charges to access a congested area within a city. Pricing by means of level of congestion and on a per mile charge within an area is referred to as area-wide charges (17). The area-wide charges are being explored in Oregon and may replace the fuel tax in the future. Many people consider public transit or take other routes to avoid the congestion pricing which helps reduce congestion in the pricing area. London has seen benefits from the implementation of congestion pricing in February of 2003. The highly congested area of the city looked to cordon charges to alleviate the problem. The system uses technological practices to make the plan successful. Payments can be made at retail outlets or motorists can purchase passes with discounts. Video cameras in the area record the license plate numbers and match them with the paid lists or fines are mailed to individuals not following the pricing procedure (18). The charges to access the downtown area have produced great benefits for the city including another revenue source and reduced congestion.

CONCLUSION

Highway congestion continues to have a significant impact on society, our environment and the freight movement within the nation. The issue continues to cost the nation several dollars and will continue to grow if it is not quickly controlled. The Federal Government needs to continue launching congestion mitigation programs and support more aggressive funding to curb the problem that continues to put limits on the transportation system. As research continues it is hopeful that innovative tactics and strategies will be discovered to slow the growing trend of highway congestion. The public needs to be educated on the congestion issue and the impact that is has on everyone's live whether you live in an urban or rural area. Highway congestion plagues the transportation system of this nation and will have a greater effect on the public if congestion mitigation strategies and tactics are not implemented in the next few years.

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