Benefits and Costs of Full Operations and ITS Deployment

A 2025 Forecast for Tucson

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Preface

People who live in urban areas nationwide report that traffic congestion is one of their greatest quality-of-life concerns. When the demand for travel in a region exceeds the available capacity of the transportation system, residents suffer from excessive travel times, increased crash risks, diminished air quality, and other negative impacts. State and local transportation agencies have found it difficult to increase the transportation system supply rapidly enough to keep pace with the growing demand. Traditional approaches such as adding highway lanes, building new roads, or providing new transit lines are often too costly to be considered as reasonable solutions, particularly in the more densely populated areas of major cities. Transportation agencies are further challenged by the time required to design and construct these traditional infrastructure improvements.

In response to this dilemma, transportation agencies have increasingly turned to improved operational strategies and Intelligent Transportation Systems (ITS) in order to squeeze more operational efficiency out of the existing transportation system. Examples of these operations and ITS strategies include synchronizing the timing of traffic signals to smooth traffic flow, providing incident response vehicles such as freeway service patrols to quickly clear traffic incidents and breakdowns, automatically tracking and dispatching transit buses to improve their on-time performance, and providing meaningful traveler information to the public to allow travelers to better plan their trips. ITS America, the professional organization founded to facilitate the successful deployment of such systems, defines ITS as follows:

"Intelligent transportation systems encompass a broad range of wireless and wireline communications-based information, control and electronics technologies. When integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternate routes to travelers, enhance productivity, and save lives, time and money."[1]

Information technology has contributed to efficiency gains in a wide range of industries, and ITS produces similar results for transportation. ITS solutions can be implemented more quickly and less expensively in comparison to traditional infrastructure improvements, and nationwide deployments of ITS have been shown to produce significant benefits. By themselves, these operations and ITS strategies will not eradicate congestion; however, they are essential components to a well-balanced, well-operating transportation network.

Furthermore, these individual operations and ITS improvements can be tied together to achieve even greater benefit than they can alone. Recognizing that the whole is often greater than the sum of its parts, the United States Department of Transportation (U.S. DOT) and numerous local agencies have launched initiatives to encourage deployment and integration of these systems in order to maximize their potential benefits.

[1] ITS America website: www.itsa.org.

The goal of full deployment and complete integration of ITS, however, has yet to be realized in any metropolitan area. Financial constraints, along with technical and institutional barriers, have held up achievement of this goal. Operations and ITS implementation have typically advanced incrementally within communities, targeting the highest priorities first while deferring enhancements until additional resources are available. This piecemeal approach has hindered or sometimes prevented the integration of the individual deployments, preventing the region from experiencing the full potential of benefits from a coordinated and complementary system.

To date, the analysis and evaluation of operations and ITS deployments have followed a similar path—often focusing on the benefits of a single ITS technology used in a single location. As a result of this narrow focus, very little information exists that exemplifies the benefits of increased deployment and integration of operations and ITS strategies.

As a result, the Federal Highway Administration (FHWA) initiated a study to explore the benefits and costs of fully deploying operational strategies and integrating ITS in metropolitan areas. The goal of this effort is to provide transportation professionals and decision makers with a better understanding of the potential benefits of implementing the full suite of available operations and ITS strategies in a metropolitan area.

The U.S. DOT selected Tucson, Cincinnati, and Seattle for case studies representing small, medium, and large metropolitan areas, respectively. Scenarios were identified comprising complete operations and ITS deployment at an appropriate, logical scale for each area. These scenarios were then evaluated to estimate the regionwide benefits and costs.

Beyond the difference in the size of the three metropolitan areas, some additional variations in the analysis approach affected the relative benefits estimated in each case study area. Benefits were estimated in the Tucson example based on forecasts of traffic in the year 2025, while the benefits for Cincinnati and Seattle were based on more current (2003) traffic conditions. The Cincinnati study also includes the additional analysis of impacts during inclement weather conditions and construction activity, as well as the added benefits of weather and work zone mitigation strategies—strategies that are not included in the deployments for Tucson or Seattle.

This report presents the findings of the Tucson, Arizona scenario. The findings of the Seattle scenario are presented in *Benefits and Costs of Full Operations and ITS Deployment: A 2003 Simulation for Seattle* (FHWA-JPO-04-033, EDL# 13977). The findings of the Cincinnati scenario are presented in *Benefits and Costs of Full Operations and ITS Deployment: A 2003 Simulation for Cincinnati* (FHWA-JPO-04-031, EDL# 13979).

Evaluation Approach

The analysis compares the Full Operations and ITS Deployment Scenario to one that contains no operations and ITS deployment whatsoever.

How Were Operations and ITS Strategies Selected?

The first step in evaluating the benefits of full operations and ITS deployment in Tucson was to identify the suite of ITS improvements that would constitute "full deployment" in the year 2025.[2] Tucson's current and planned operations and ITS improvements were inventoried to serve as the building blocks for the full deployment scenario. These elements were then enhanced and expanded by identifying additional improvements to fill gaps, upgrade the existing systems with more advanced technologies, and then integrate the diverse systems. The result was the establishment of the Full Operations and ITS Deployment Scenario, defined as the maximum amount of locally desirable operations and ITS—at the highest range of technical and institutional sophistication—that can be deployed without regard to funding constraints.

Several additional guidelines were used in identifying the appropriate amount of operations and ITS to include in the full deployment scenario in order to avoid making overly optimistic assumptions about future benefits. First, the Full Operations and ITS Deployment Scenario includes only those strategies that are funded or significantly subsidized by the public sector. Private sector strategies, such as in-vehicle navigation or safety systems in personal automobiles, or freight management systems used by commercial trucking firms, were not considered.

Although the benefits of these systems are not included in this analysis, they are expected to offer significant benefits.

In addition, another limitation of the Full Operations and ITS Deployment Scenario was that technologies and approaches which have not currently progressed past development and testing were not included because of a lack of industry consensus on their future costs, benefits, and market penetration. New operations and ITS strategies are emerging constantly due to the ever-changing nature of technology; however, those evaluated in this study include only well-established systems that are currently in use throughout the nation. These assumptions lead to a conservative estimation of benefits in 2025, because technical innovation will likely result in systems that can provide even greater benefit for the same or less cost than current technologies.

How Were the Benefits Estimated?

The analysis of the benefits and costs for the Full Operations and ITS Deployment Scenario was conducted using the ITS Deployment Analysis System (IDAS). The IDAS tool is specifically designed to estimate the benefits and costs of ITS deployments based on observed, real-world costs and benefits. This analysis tool was used to estimate benefits, including changes in travel time, travel time reliability, number and severity of crashes, vehicle emissions, fuel use, and other important measures.

[2] The year 2025 was selected as the future year due to the availability of detailed traffic forecasts and models for the Tucson region for that year.

The analysis compares the Full Operations and ITS Deployment Scenario to one that contains no operations and ITS deployment whatsoever. This "all-or-nothing" approach was used to compare the complete costs and benefits of operations and ITS in Tucson. This approach further allows the findings to be applicable to other regions that may be at different stages of operations and ITS deployment.

A Technical Appendix accompanying this report provides additional detail on the methodology used in estimating the benefits and costs.

Tucson's Full Operations and ITS Deployment Scenario

The strategies included in Tucson's Full Operations and ITS Deployment Scenario were identified by first consulting with local agencies to identify the overall ITS program planned through 2025. To date, the Tucson metropolitan area has successfully deployed a variety of operations and ITS strategies and has adopted relatively aggressive plans for geographic expansion and enhancement in the future. The region is particularly advanced in the deployment of traffic signal coordination along its many arterial streets. The low-density development of many of Tucson's neighborhoods that are not conveniently served by the freeway required Tucson to aggressively pursue the deployment of advanced traffic signal control and coordination technologies.

Tucson's existing and planned operations and ITS improvements provided a solid basis for identifying additional strategies, geographic coverage, and technology upgrades that could naturally be built upon to create the Full Operations and ITS Deployment Scenario. Table 1 presents the strategies selected and the number of deployment locations for Tucson in the year 2025. The proportional coverage on the system is also presented to portray the ITS deployment density level relative to the entire system.

Table 1. Strategies Included in the Tucson Full Operations and ITS Deployment Scenario

Strategy	Deployment	Coverage
Arterial Traffic Management Systems		
Central Control Signal Coordination	600 intersections	100% of major intersections; 96% of major arterial and parkway miles
Emergency Vehicle Signal Preemption	600 intersections 1,340 emergency vehicles	100% of major intersections; 96% of major arterial and parkway miles 100% of emergency vehicles
Transit Vehicle Signal Priority	115 intersections 80 transit vehicles	9 of 37 routes served (24% routes) 29% fixed-route transit vehicles
Highway Advisory Radio	1 transceiver	100% of arterial miles covered
Dynamic Message Signs	40 locations	100% of arterial incident management corridors and roadways subject to major flood
Freeway Management Systems		
Central Control Ramping Metering	70 on-ramps	73% of on-ramps
Highway Advisory Radio	1 transceiver	100% of freeway miles
Dynamic Message Signs	9 locations	100% of freeway miles
Transit Management Systems		
Fixed-Route Automated Scheduling and Automatic Vehicle Location	275 transit vehicles 5 transit stations	100% fixed-route transit vehicles 100% of transit transfer stations
Transit Management Systems		
Incident Detection, Verification, Response, and Management	20 freeway service patrol vehicles	100% of freeway miles: 15% of parkway and major arterial miles (110 of 721 miles)
Transit Management Systems		
Emergency Vehicle Control Service	1,340 emergency vehicles	100% of emergency vehicles
Emergency Vehicle AVL	1,340 emergency vehicles	100% of emergency vehicles
Telemedicine	130 ambulances	100% ambulances
Transit Management Systems		
Electronic Transit Fare Payment	275 transit vehicles	100% of fixed-route transit vehicles
Traveler Information		
Telephone- and Web-based Traveler Information System	Regionwide	40% of market penetration
Kiosk-based Traveler Information	5 kiosks	100% of transit transfer stations
Crash Prevention and Safety		
Railroad Crossing Monitoring Systems	4 rail crossings	5% of major grade crossings

Table 1. Strategies Included in the Tucson Full Operations and ITS Deployment Scenario (Cont'd from page 7)

Strategy	Deployment	Coverage
Commercial Vehicle Operations		
Weigh-in-motion and Safety Information Exchange	1 check station	N/A
Combination Screening and Clearance–Credentials and Safety	1 check station 53,000 equipped commercial vehicles	N/A 40% market penetration
Supporting Deployments		
Traffic Management Center	One	100% of region
Transit Management Center	One	100% of region
Emergency Management	One	100% of region
Information Service Provider Center	One	100% of region
Traffic Surveillance–Closed Circuit Television	950 locations	100% of freeway, parkway, and major arterial miles
Traffic Surveillance–Loop Detectors	1,200 locations	100% of freeway miles; 96% of parkway and major arterial miles; 100% controlled signals

Benefits of Full Operations and ITS Deployment

What Would Be the Benefits?

The performance of the Tucson transportation system in the year 2025 was analyzed for two cases—No Operations and ITS Deployment and the Full Operations and ITS Deployment Scenario. The results from the two scenarios were then compared to identify the incremental change due to the inclusion of operational improvements and ITS deployment.

The analysis of the Full Operations and ITS Deployment Scenario showed positive impacts on all performance measures studied, including:

- Decreased travel times
- Increased vehicle speeds
- Decreased delay
- Decreased number and severity of crashes
- Decreased environmental impacts (reduced emissions and fuel use).

The following sections discuss these impacts in greater detail.

Decreased Travel Times

Personal travel time in the region decreased significantly as a result of full operations implementation and ITS deployment. On average, more than 36,000 hours of travel time were saved on a daily basis in the Tucson region. This amounts to more than 9 million person-hours saved annually, or a reduction of more than 7 hours per resident annually in the Tucson region. All travel modes (automobiles, commercial trucks, and transit) were predicted to experience reduced travel time under the full ITS deployment scenario. In particular, transit riders were expected to experience significant travel time improvements. Transit riders saved an average of about 5 minutes every trip, approximately 30 percent of their average trip time.

Increased Vehicle Speeds

Average vehicle speeds throughout Tucson's roadway network increased slightly as a result of the operations and ITS deployments. However, the majority of the speed increase was observed on major facilities, including freeways, parkways, and major arterials which served as a focus of a number of the ITS and operations improvements. For example, speeds increased by as much as 10 percent on some congested segments of Interstate 10, which serves as the primary freeway in the region. The minor arterials and collectors, which received fewer improvements, experienced positive but less significant speed increases. Consequently, the overall network speed impact was moderated by the smaller increase on the local street system. Freeway ramp facilities were the only roadway type to experience a small decrease in speeds, which likely occurred as a result of the addition of ramp metering strategies. (Ramp metering briefly stops vehicles on the on-ramp to manage the traffic flow onto the freeway and smooth the merge.)

Decreased Delay

The ITS and operations strategies were shown to significantly reduce delay in the region. This reduction included a decrease in the delay due to recurring congestion as well as a decrease in the delay caused by unexpected traffic incidents. The amount of delay due to everyday, recurring congestion was reduced by 5.6 percent for roadway users in the Tucson region. Consistent with the observed speed changes, the reductions in delay were greatest on

Consistent with the observed speed changes, the reductions in delay were greatest on primary roadways that received the greatest concentration of ITS and operations deployments.

primary roadways that received the greatest concentration of ITS and operations deployments. For example, delay was reduced on freeways in the region by 10.6 percent, while delay on major arterial roadways and parkways was reduced by 6.4 percent. Less significant reductions in delay were observed on more minor, local streets in the region.

In addition to the impacts on delay related to everyday congestion, many operations and ITS strategies are intended to reduce incident-related delay by either decreasing the number of crashes occurring on the network or minimizing the time required to respond and clear incidents once they do occur. Full deployment in the Tucson region resulted in a dramatic reduction of incident-related delay, an average reduction of more than 11,500 hours per day. Incident delay, which was only estimated for freeways, was reduced by more than 70 percent by the use of operations and ITS. Figure 2 shows the reduction in hours of everyday recurring delay along with the reduction in hours of incident related delay on the freeways.

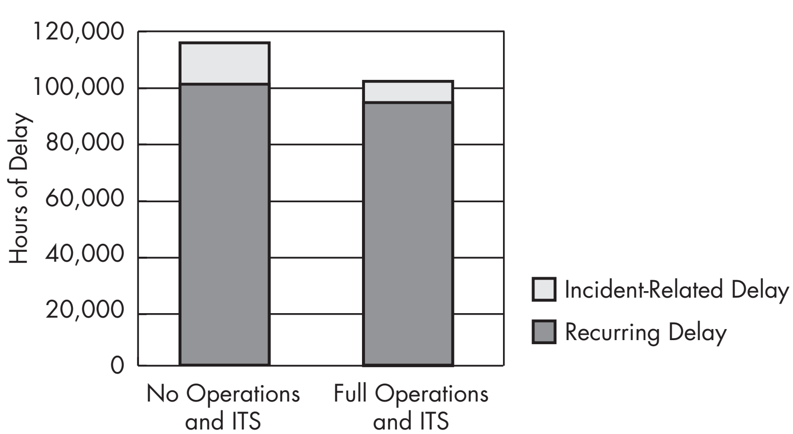
Decreased Number and Severity of Crashes

Operations and ITS improvements were predicted to significantly reduce the number of traffic crashes occurring in the Tucson region. Additionally, through the deployment of incident and emergency management systems, which minimize the response time to crashes, the severity of crashes was also reduced. Overall, fatal crashes decreased by more than 7 percent, while injury and property damage crashes were reduced by approximately 3 percent. Full operations and ITS deployment resulted in the avoidance of approximately 11 fatal, 400 injury, and 540 property damage crashes per year in the Tucson region.

Decreased Environmental Impacts

Operational improvements and ITS resulted in a reduction for all emissions analyzed. Carbon monoxide and hydrocarbon emissions were reduced by approximately 10 and 12 percent, respectively, while nitrous oxides were reduced by more than 16 percent. Fuel use was cut by more than 11 percent, representing a savings of more than 56 million gallons of fuel per year, or nearly 60 gallons per resident in the Tucson region.

Figure 1. Reduction in Hours of Delay Due to Operations and ITS Deployments



Note: Incident-related delay represents only the hours of delay on the regional freeways.

What Would Be the Value of the Benefits?

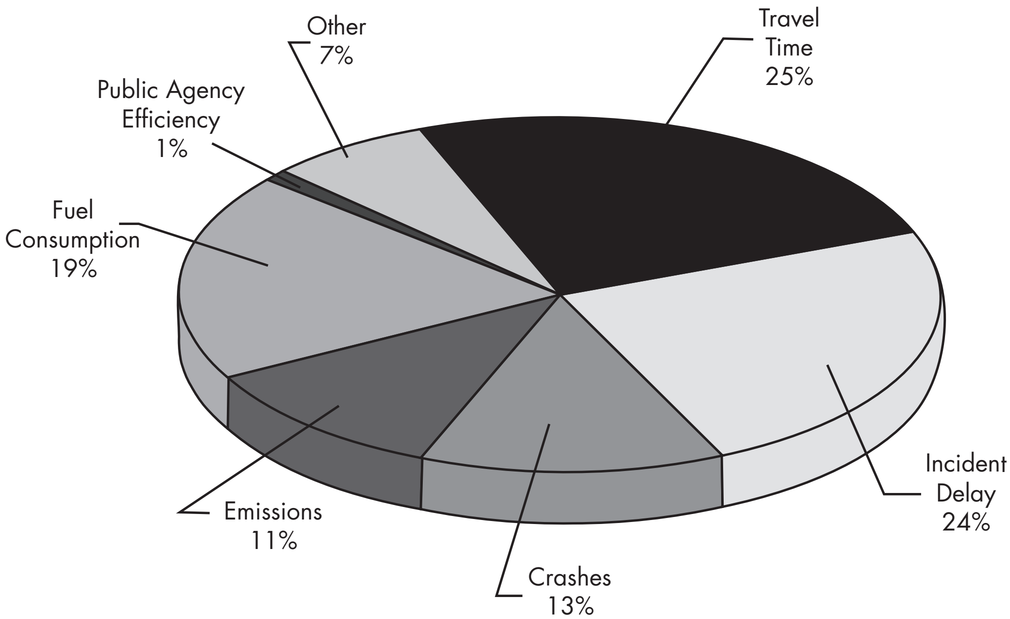
The monetary value of the benefits of Full Operations and ITS Deployment in Tucson was estimated by applying a dollar value to the impacts. For example, the estimated number of gallons of fuel saved per day was multiplied by the number of days per year and by the cost of a gallon of fuel.

When the impacts of the operations and ITS deployments are annualized and dollar values are applied, the benefits total more than $455 million per year for the Tucson region. The values of the studied benefits are presented in Table 2. The percentage of the value of each benefit compared to the total is presented in Figure 3.

Table 2. Annual Benefits of Operations and ITS Deployment in Tucson (in $ Millions in 2003 dollars)

Benefit	Value
Reduction in travel time (Mobility)	$113
Reduction in incident delay (Reliability)	$110
Reduction in crashes (Safety)	$57
Reduction in emissions (Environment)	$50
Reduction in Fuel Consumption (Energy)	$86
Increase in public agency efficiency (Productivity)	$7
Other[3]	$33
Total Benefits	**$481**

Figure 2. Proportion of Benefits Value in Tucson



[3] Other estimated benefits include reduced noise, decreased non- fuel operating costs, and additional safety benefits associated with decreased emergency vehicle response time.

Costs of Full Operations and ITS Deployment

The average costs of implementing operations and ITS in Tucson were estimated to be $72 million annually. These costs represent an annualized life-cycle cost of the resources necessary to implement, operate, and maintain them. Although the strategies included in this analysis were primarily funded by the public sector, a portion of the costs was expected to be paid for by the private sector. These private sector costs include the equipment needed on commercial trucks to enable the use of automated screening and clearance deployments at check stations. The considerable number of commercial trucks assumed to be equipped in the full deployment scenario (53,000) influenced the substantial estimated cost for this equipment. Table 3 presents the costs for the Full Operations and ITS Deployment Scenario in Tucson.

Supporting deployments presented in Table 3 represent the backbone infrastructure necessary to operate and manage the deployed strategies. These include items such as traffic management centers, traffic surveillance cameras, and communication systems.

How Do the Costs and Benefits Compare?

When the annual estimated benefits are compared to the costs, the results show the investment in operations and ITS in Tucson

Table 3. Annual Cost of Operations and ITS Deployments in Tucson (In $ Millions in 2003 Dollars)

Deployment	Cost	Percentage of Total Costs
Arterial management systems	$3.9	5.5%
Freeway management systems	$2.6	3.6%
Transit management systems	$1.8	2.6%
Incident management systems	$4.5	6.2%
Emergency management systems	$2.1	2.9%
Electronic payment systems	$1.1	1.0%
Traveler information	$2.1	2.9%
Crash prevention and safety	$0.2	0.3%
Commercial vehicle operations	$20.3	28.1%
Supporting deployments	$33.5	46.4%
Total costs	$72.1	100.0%
Private sector costs	$19.8	27.4%
Public sector costs	$52.3	72.6%

to be quite favorable and cost efficient. The benefits of the deployment outweigh the costs by a ratio of 6.3 to 1, as shown in Table 4. This ratio indicates that each dollar spent on operations and ITS in the Tucson region would return $6.30 in benefits from decreased travel time, improved safety, and a reduction in vehicle emissions and fuel consumption.

The benefits estimated for the full deployment of operations and ITS in Tucson were overwhelmingly positive when compared with the costs. The conservative treatment of several factors related to the analysis suggests that future benefits of operations and ITS may be even greater. These assumptions include:

- The analysis only considered those operations and ITS deployments that are funded or significantly subsidized by the public sector. Many additional private sector ITS initiatives are currently deployed or planned, but were not considered in this analysis. These private sector deployments, such as in-vehicle navigation and safety systems, and commercial vehicle tracking and dispatching, would likely provide benefits beyond those presented in this report.

- The analysis did not attempt to predict the capabilities or costs of future technology. Instead, the analysis considered the impact of deploying currently available technologies at a greater rate than presently deployed. Benefits and costs of the deployments were based on currently observed impacts and equipment costs. Presumably, future advances will provide greater capabilities at lower costs.

The benefits of the deployment outweigh the costs by a ratio of 6.3 to 1.

Table 4. Comparison of Annual Benefits and Costs in Tucson (In $ Millions in 2003 Dollars)

Average annual benefit	$455
Average annual costs	$72
Benefit-cost ratio	6.3

Summary

This analysis examined the potential benefits and costs of fully deploying and integrating operations and ITS strategies in the Tucson region. A Full Operations and ITS Deployment Scenario was identified for the year 2025 and compared to a scenario without any operations and ITS deployments in order to identify the changes in impacts. The results showed the investment in ITS to be cost-efficient—returning $6.30 in benefits for every dollar invested.

Operations and ITS strategies were shown to have a positive impact in reducing travel time delays caused by incidents, as well as reducing travel times during normal conditions. By reducing the amount of time people spend stuck in congestion, operations and ITS would also reduce the frustration of travelers and likely have a positive influence on regional productivity. Reductions in crashes, vehicle emissions, and fuel use would further contribute to improvements in the quality of life in the Tucson region.

The benefits estimated for the full deployment of operations and ITS in Tucson were overwhelmingly positive when compared with the costs. The conservative treatment of several factors related to the analysis suggests that future benefits of operations and ITS may be even greater.

For More Information

Additional information on the operations and ITS strategies discussed in this report can be obtained through the FHWA's Office of Operations www.ops.fhwa.gov and through the U.S. Department of Transportation's ITS Joint Program Office www.its.dot.gov. For additional information on the individual benefits and costs of the ITS deployments presented in this report, please visit the ITS Joint Program Office's ITS Benefits and Costs Database at www.benefitcost.its.dot.gov. More information on the IDAS analysis tool used in this evaluation may be found at idas.camsys.com. Please visit the ITS Deployment Tracking website www.itsdeployment.its.dot.gov for more information on the current and historical levels of operations and ITS deployment in U.S. metropolitan areas.

Technical Appendix

Background

This Technical Appendix provides a general overview of the methodology used in the study of the potential benefits of fully deploying operations and ITS strategies. This study was initiated by the U.S. DOT to explore the benefits and costs of fully deploying and integrating ITS and operations strategies in metropolitan areas. Three test sites—Tucson, Arizona; Cincinnati, Ohio; and Seattle, Washington—were selected to represent small, medium, and large metropolitan areas, respectively. Hypothetical deployment scenarios were developed to represent the full logical deployment of operations and ITS strategies in each area. These scenarios were then evaluated to identify the likely benefits and costs of the deployments. The goal of this study was to provide transportation professionals and decision makers with an increased understanding of the potential benefits possible through the full deployment of ITS and operations strategies.

The findings from these three case studies are summarized in individual reports. This appendix provides additional detail on the similar approach used in all three regions to estimate the likely benefits and costs of full operations and ITS deployment.

Methodology Overview

The goal of this analysis was to estimate the likely benefits and costs resulting from the full deployment and integration of ITS and operations strategies in a region. For the purpose of this study, "full deployment" is defined as the maximum amount of locally desirable ITS and transportation operations strategies—at the highest range of technical and institutional sophistication—that can be deployed without regard to funding constraints. Consistent with this goal and definition, full operations and ITS deployment scenarios were identified for the three case study regions.

The analysis methodology used in this study was developed to identify the incremental benefits and costs of the strategies contained in the full operations and ITS deployment scenario. To identify these incremental impacts, it was necessary to estimate what travel conditions would be in the full operations and ITS deployment scenario, as compared with a scenario that did not contain any operations and ITS deployments. This "all-or-nothing" approach was used to isolate the full costs and benefits of the operations and ITS deployments.

The FHWA's ITS Deployment Analysis System software was used in conjunction with the locally validated travel demand models for the three case study regions to predict the traffic conditions that would be likely in the two deployment scenarios—the No Operations and ITS Deployment Scenario and the Full Operations and ITS Deployment Scenario. An overview of the IDAS tool analysis process is provided in a subsequent section.

This analysis approach resulted in numerous regional performance measures being estimated for the two scenarios, such as the person hours of travel, roadway speeds, the number of crashes, and the gallons of fuel used, among others. To identify the incremental impact resulting from the deployment of ITS, the performance measures from the Full Operations and ITS Deployment Scenario were subtracted from the identical performance measures for the No Operations and ITS Deployment Scenario. The difference between the performance measures of the two scenarios represented the incremental impact caused by ITS during the day or time period represented by the model data. The annual impact was determined by multiplying the daily incremental impact by the number of days per year.

For example, the Tucson case study used a single daily model in the analysis. To estimate the impact on any particular performance measure, such as the number of fatality crashes, the following approach was used:

- *Annual Benefit = (Number of Fatality Crashes Occurring in the No Operations and ITS Deployment Scenario – Number of Fatality Crashes Occurring in the Full Operations and ITS Deployment Scenario) * Number of Days Per Year*

For those models having multiple time periods represented within a day, separate No Operations and ITS Deployment and Full Operations and ITS Deployment Scenarios were developed for each time period. The performance measure for the No Operations and ITS Deployment and the Full Operations and ITS Deployment Scenarios were then compared within each time period to identify the incremental impact. The incremental impacts from all the available time periods summed up the daily impact.[A-1] This summed figure was then multiplied by the number of days per year to annualize the benefit. An example of this approach for annualizing the results for models with multiple time-of-day analysis is shown below:

$$\text{Annual Benefit} = \sum \begin{bmatrix} \text{AMNo} - \text{AMFull} \\ \text{MDNo} - \text{MDFull} \\ \text{PMNo} - \text{PMFull} \\ \text{OPNo} - \text{OPFull} \end{bmatrix} * \text{Number of Days Per Year}$$

Where:

- *AMNo = performance measure from the AM Peak Period – No Operations and ITS Deployment Scenario*
- *AMFull = performance measure from the AM Peak Period – Full Operations and ITS Deployment Scenario*
- *MDNo = performance measure from the Mid-day Period – No Operations and ITS Deployment Scenario*
- *MDFull = performance measure from the Mid-day Period – Full Operations and ITS Deployment Scenario*
- *PMNo = performance measure from the PM Peak Period – No Operations and ITS Deployment Scenario*
- *PMFull = performance measure from the PM Peak Period – Full Operations and ITS Deployment Scenario*
- *OPNo = performance measure from the Off-Peak Period – No Operations and ITS Deployment Scenario*

[A-1] The summing of the performance measures across all time periods was performed for all cumulative impacts. Non-cumulative performance measures, such as vehicle speeds, were not summed. Instead, these performance measures were calculated from the cumulative performance measures. For example, the estimate of daily speed was determined by summing the vehicle miles traveled (VMT) for all periods and dividing by summed vehicle hours traveled (VHT) for all periods.

- *OPFull = performance measure from the Off-Peak Period – Full Operations and ITS Deployment Scenario*

The value of the annual benefit was then determined by applying the appropriate benefit values from the IDAS tool to the incremental change in the performance measures. The values from all the various performance measures were summed to determine the total annual benefit of all operations and ITS strategies included in the Full Operations and ITS Deployment Scenario. This benefit value was compared with the annual cost of the strategies to present the benefit/cost ratio for the included strategies.

IDAS Overview

What is IDAS?

The IDAS software was developed by the FHWA as a tool focused on analyzing the specific impacts of ITS. IDAS operates as a post-processor to travel demand models used by metropolitan planning organizations and by state departments of transportation for transportation-planning purposes. IDAS is intended to mimic and build upon the results of these tools, and shares many of the same analysis techniques and processes. Although a sketch-planning tool, IDAS implements the modal split and traffic assignment steps associated with a traditional planning model. These steps are key to estimating the changes in modal, route, and temporal decisions of travelers resulting from ITS technologies.

IDAS was developed as a tool specifically focused on analyzing the specific impacts of ITS. IDAS was also designed to serve as a repository of information on the impacts of various types of ITS deployments and of the costs associated with various types of ITS equipment. The default ITS impacts and costs used in the IDAS tool are based on the observed experiences of deploying agencies, as maintained in the U.S. DOT's ITS Benefits and Costs Database, www.benefitcost.its.dot.gov. By offering these capabilities, IDAS provides the ability to critically analyze and compare different ITS deployment strategies, prioritize the deployments, and compare the benefits of the ITS deployments with other improvements to better integrate ITS with traditional planning processes.

How Does IDAS Work?

The IDAS tool works by importing the results from travel demand models in order to recreate the validated regional network structure and travel demand within IDAS. The data are imported into IDAS using a special internal input/output interface, which is capable of reading and interpreting ASCII text data files. These input data files are created from data generated by the regional travel demand models. The data exchanged between the travel demand model and IDAS include network data regarding the characteristics of transportation facilities in the region and travel demand data, including the number of trips and mode share of travel between different zone pairs in the model. Depending on the needs of the analysis and the format of the available data, the user is typically required to perform some data conversion prior to import into IDAS. Once the data are imported, they are stored in a database accessible by the IDAS software and may be viewed in a graphical output by the user.

Once the data input is complete, IDAS is capable of operating independently of the travel demand model. The IDAS user is then able to create analysis alternatives by selecting ITS components from a menu of more than 60 ITS improvements, and placing these on the desired location on the network. The user then provides additional information regarding their deployment, such as the implementation date and proposed operational strategies.

Once the analysis alternative has been created, the IDAS software then modifies the network or travel characteristics to represent the likely impacts of the ITS deployments placed on the network by the user. These modifications are based on real-world impacts observed in other regions following their deployment of similar ITS components, and may include changes in link capacities or speeds, zone-to-zone travel times, crash or emissions rates, or other impacts specific to the ITS component. The specific default impacts associated with each of the various ITS deployments are described in *Appendix B – IDAS Default Values* of the *IDAS User's Manual* available on the IDAS software website idas.camsys.com.

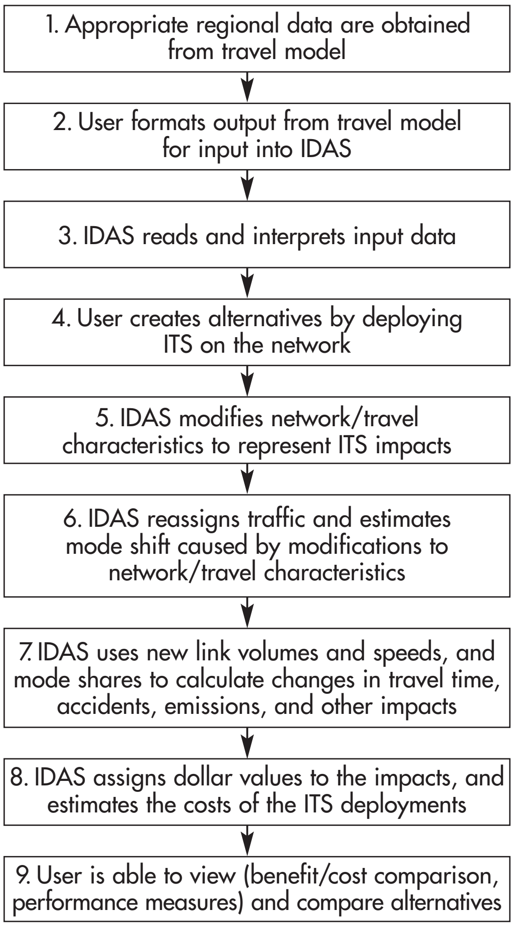
The IDAS model then uses analysis techniques similar to the travel demand models to analyze the impacts created by the modifications to the alternative network and travel characteristics. A traffic assignment routine is used to estimate the changes in travel patterns caused by the modifications, and a mode shift routine is used to estimate any travel mode changes. The results of this analysis are revised link volumes and speeds and mode shares. IDAS conducts the same analysis procedures on the unmodified, baseline network (without ITS deployments) as well as the modified alternative network (with ITS deployments). These two scenarios are then compared to identify the incremental impact resulting from the ITS deployment.

The changes in link volumes and speeds and mode shares are then used by IDAS in another series of analysis to calculate changes in the travel time, the number of crashes, the amount of emissions and other impacts. Dollar values are then applied by IDAS to these impacts to provide an estimate of the benefits of the ITS components deployed in the alternative.

In a separate process, the costs of the ITS deployments are also estimated by IDAS. The costs of the ITS deployments are calculated by identifying the inventory of equipment necessary to deploy and operate each improvement, based on the suggested equipment packages in the ITS National Architecture. IDAS then applies unit costs (capital and operations and maintenance [O&M] costs) to each piece of equipment in the inventory and annualizes the capital costs based on the anticipated useful life of the equipment.[A-2] The costs of all equipment included in the inventory for a particular deployment alternative are summed and compared with the benefits in the form of a benefit/cost ratio. These outputs are summarized and displayed to the user in several formats. The complete IDAS analysis process is summarized in Figure A-1.

[A-2] IDAS equipment unit costs are periodically updated to represent the latest costs reflected in the U.S. DOT's ITS Benefits and Costs Database: www.benefitcost.its.dot.gov.

Figure A-1. IDAS Analysis Process



Additional information regarding the structure of IDAS and its processes is presented in the *IDAS User's Manual*, which is distributed electronically with the IDAS software, or is available on the IDAS website at idas.camsys.com.

Use of IDAS in Analyzing the Impacts of Full Operations and ITS Deployment

Except where noted, the analysis of the impacts of full operations and ITS deployment used the default IDAS procedures, parameters, and impacts. These parameters and impact values were held constant in the three case study regions in order to produce comparable results.

The following exceptions to the standard IDAS methodology were made in the analysis:

- Estimation of Costs – A separate cost estimation spreadsheet tool was developed outside the IDAS software to calculate the cost of the operations and ITS deployments. This spreadsheet tool applied the same methodology and used the identical equipment unit costs as the IDAS software. This external spreadsheet method was used to improve the ease of use for the analysts, and better account for particular ITS equipment not currently represented in the IDAS software.

- Estimation of the Impacts of Advanced Traveler Information Systems (ATIS) – A blanket assumption of the overall effectiveness of all ATIS deployments was made, rather than make individual assumptions regarding the likely market penetration and effectiveness of each individual component. It was assumed that the various deployed ATIS components (pre-trip and in-route systems) were successful in reaching 40 percent of travelers. Of those travelers receiving the information, 25 percent were able to save 6.3 percent of their travel time. This impact assumption was based on a comparison of the various IDAS impact assumption values for the individual ATIS components.

- Estimation of Benefit/Cost – An external spreadsheet tool was developed to compare the benefits and costs for the full deployment scenario. This separate spreadsheet was needed in order to aggregate the results from multiple IDAS runs representing different time periods

(A.M., P.M., etc.). IDAS currently only has the ability to compare benefits and costs for a single time period. This spreadsheet compiled the results from multiple time-period scenarios into combined daily and annual results.

- Estimation of the Impacts of Weather and Work Zone Mitigation Strategies – Weather and work zone mitigation strategies are not currently available as deployments within the IDAS software. Special analysis techniques were developed, using capabilities within the IDAS software, to analyze the impacts of these specific strategies. These techniques are described in a subsequent section.

- Estimation of the Incident-Related Delay on Freeway Facilities – The IDAS software contains a default methodology and parameters for estimating the incident related delay for freeway facilities. Although previous IDAS studies conducted by numerous agencies have served to vet these impacts as reasonable representations for individual deployments, this study includes combinations and intensities of deployment that exceed any that have been tested using this methodology. It was the opinion of an expert panel that reviewed the preliminary results that the initial estimates of the cumulative impact to incident related delay overstated the potential reduction. In order to ensure a conservative estimation of benefits, a sensitivity analysis was performed to identify the default impact parameters used in IDAS that were most likely to result in an overestimation of benefits. These parameters were modified and the model analysis was re-run to produce the more reserved final results.

Model Networks and Adjustments

Network and travel demand data from the regional travel demand models formed the basis of the analysis. These models varied from region to region in their size and complexity. Additionally, some adjustments were necessary to modify the available travel demand model data to match the specific needs of the desired analysis. This section summarizes the models used in the three regions and describes the necessary modifications to generate the baseline data needed for the analysis.

Tucson

The model data available for the Tucson region represented daily travel conditions in the year 2025. This model was developed and maintained by the Pima Association of Governments (PAG). The Tucson model was the smallest of the models used in the analysis, representing a daily total of approximately 5.4 million person trips traveling between 870 possible origins and destinations. Three vehicle modes were represented in the model, including: Auto, Light Truck, and Heavy Truck. Two public transit modes were represented; however, both represented bus travel. The transit modes were differentiated by the form of access to the transit stop: Transit Walk Access and Transit Drive Access.

No significant modifications were required to prepare the Tucson model data for use in the analysis. Minor reformatting of the data was performed to prepare the data for input into the IDAS software tool.

Cincinnati

The Cincinnati region model, obtained from the Ohio-Kentucky-Indiana Regional Council of Governments (OKI), was the most complex of the three regional models used in the analysis. The model had recently undergone a significant update, which resulted in the merging of the regional travel demand models representing the Cincinnati and Dayton, Ohio, regions. Models were specifically developed for this analysis representing travel demand for the year 2003. These models were developed to represent four separate time periods: A.M. Peak Period (2.5 hours), Mid-day Peak Period (6.5 hours), P.M. Peak Period (3.5 hours), and Off-Peak Period (11.5 hours). The combined travel demand in these four periods represented approximately 9.3 million daily person trips traveling between 2,999 possible origins and destinations. Approximately 69 percent of this travel occurs in the Cincinnati region.

Adding to the complexity of the Cincinnati model was the disaggregation of travel into 11 possible modes, including five vehicle modes: Single Occupancy Vehicle, High Occupancy Vehicle (two people), High Occupancy Vehicle (three or more people), Single-Unit Truck, and Multiple-Unit Truck. Six separate bus transit modes were also available, segmented by the type of bus service and access mode, including: Local Bus Walk Access, Local Bus Park & Ride, Local Bus Kiss & Ride, Express Bus Walk Access, Express Bus Park & Ride, and Express Bus Kiss & Ride.

Several significant modifications were made to the existing Cincinnati models to prepare the data for use in this analysis. The first modification was the development of models representing travel in the year 2003. No specific existing models were available representing this year. Travel demand from models representing the year 2000 and 2010 were interpolated to develop travel demand trip tables for each of the analysis periods representing the year 2003. The model networks from the 2000 models were used since these models already contained roadway improvements that were expected to be completed by 2003.

A second modification was required to allow the analysis to focus only on the impacts in the Cincinnati region. The recent model update had merged the previous models from the Cincinnati and Dayton regions into a single model; however, the focus of this analysis was only on the Cincinnati region. A special data flag was added to the network link data to identify in which region each roadway was located. This enhancement allowed performance measures to be extracted from only those portions of the network located in the Cincinnati (OKI) region.

Other minor modifications were required to reformat the data for input into the IDAS software. Additional modifications were also required to perform a separate analysis of the impacts of weather and work zone mitigation strategies in the Cincinnati region. These specific modifications are discussed in a subsequent section.

Seattle

The Seattle regional models used in the analysis represented travel demand in the year 2003 for three separate time periods: A.M. Peak Period, P.M. Peak Period, and the Off-Peak Period. These models were based on the Puget Sound Regional Council (PSRC) travel demand models. These models represented a combined daily travel demand of approximately 10.8 million person trips traveling between 850 possible origins and destinations. Five separate travel modes were used in the analysis including: Single Occupancy Vehicle, High Occupancy Vehicle, Truck, Transit (bus and rail), and Ferry.

Several modifications were made to the existing PSRC models to generate data suitable to the analysis of full operations and ITS deployment. The first modification was the development of specific models representing travel conditions in the year 2003. Travel demand data from existing year 2000 and 2005 models were interpolated to develop these interim year models.

A second modification to the Seattle model networks was required to allow the analysis of ramp metering strategies. On-ramp facilities are not represented in the current Seattle models. Instead, these interchanges are coded similar to surface street intersections and allow traffic to move directly from arterial roadways to freeway facilities. The IDAS software typically requires that ramp facilities be coded in the network to allow the analysis of ramp metering strategies. When ramp meters are deployed, additional impedance is added to the ramp facilities to simulate the impact of the ramp signal on traffic entering the freeway. Since the ramp facilities were not available in the Seattle model network, modifications were required to properly represent this impact. Turning movement restrictions, available for use in the IDAS software, were specially modified to represent the additional impedance caused by ramp metering strategies in the absence of ramp facilities.

A final modification to the Seattle models was required to properly represent automobile carrying ferries in the IDAS analysis. Some reformatting of the model data was necessary to properly account for this specific travel mode that is prevalent in the Puget Sound region.

Additional Analysis for Estimating the Impacts of Weather and Work Zones

Analysis Scenarios

Additional analysis was conducted in Cincinnati to identify the impacts, benefits, and costs that could be expected with the addition of specialized operations and ITS strategies intended to counter the effects of inclement weather and help mitigate the negative impacts occurring as a result of road construction and maintenance.

Additional scenarios were needed to analyze these strategies because the baseline networks obtained from the travel demand model assume no inclement weather or road construction activity. The analysis scenarios that were developed differed by four separate variables: the presence of roadwork, weather conditions, deployment intensity, and time of day. These variables were defined as follows:

- Presence of Roadwork — Two separate roadwork scenarios were evaluated, including a network with a representative sample of construction activity and a network without road construction/reconstruction activity. The impact of roadwork activity was represented by reducing facility capacities through the construction zones, as described in a subsequent section.
- Weather Conditions — Three separate weather conditions were evaluated: clear, rain, and ice/snow. The network representing clear conditions was identical to the baseline network obtained from

the travel demand model. The impacts of the rain and ice/snow conditions were represented by decreasing capacities throughout the network, as described in a subsequent section.

- Deployment Intensity – Several different deployment intensities were evaluated. These include a No Operations and ITS Deployment Scenario, which did not contain any ITS or operational improvements, and a Full Operations and ITS Deployment Scenario, which contained the full compliment of operations and ITS deployments. Note that for those scenarios that contained the negative impacts of inclement weather or construction activity conditions, the deployment scenario was enhanced by adding either weather or work zone mitigation strategies, or both, as appropriate to the conditions included in the scenario. These specific mitigation strategies were not included in the scenarios that did not contain either the inclement weather or construction activity. For example, the impacts of work zone mitigation strategies were only analyzed in those scenarios with roadwork conditions.

- Time of Day – Models representing four separate time periods were available for the Cincinnati region, including A.M. Peak Period, P.M. Peak Period, Mid-day Period, and Off-Peak.

An analysis approach was developed by creating a matrix of all the potential combinations of these variables and then discarding illogical combinations. For example, no scenarios analyzing conditions representing roadwork activity during ice/snow conditions were evaluated since little construction activity is anticipated in the winter months. To accommodate these variables in the analysis, 40 separate scenarios were developed and analyzed. Table A-1 presents these scenarios.

The following sections describe how the various impacts of weather and construction activity were simulated on the network to create these scenarios.

Simulation of Weather Impacts

Three different weather situations were considered in this analysis—clear, rain, and snow. Clear weather scenarios were represented using the baseline roadway network from the TDM. Scenarios representing rain and snow weather conditions were represented by reducing the capacity of network roadways to simulate the negative impact of the inclement weather. Weather impacts on capacity represented a weighted average of suggested capacity reductions from the *Highway Capacity Manual 2000* [A-3] and the FHWA's Operations website www.ops.fhwa.dot.gov. The capacity reductions are shown in Table A-2.

Simulation of Construction Activity Impacts

The negative impacts of construction activity were simulated on the model networks by first identifying a set of construction projects that would be representative of a typical construction season. These were identified by reviewing major regional construction projects from the previous three years and selecting a set of projects representative of a typical construction season. Eight projects were selected: four lane-addition projects, two reconstruction projects, and two resurfacing projects. The construction schedules for these projects were also evaluated to estimate the typical number of days within a year in which construction activity was estimated to occur.

The construction projects were then coded into those scenarios meant to analyze work zone projects. Since the representative construction activities represent real projects, they were coded in the actual network locations they occurred. The negative

Table A-1. Cincinnati Analysis Scenarios

Weather	Construction Activity?	Scenarios with No Operation and ITS	Scenarios with Full Operation and ITS
Clear	No	A.M. Peak Mid-day P.M. Peak Off-Peak	A.M. Peak Mid-day P.M. Peak Off-Peak
	Yes	A.M. Peak Mid-day P.M. Peak Off-Peak	A.M. Peak Mid-day P.M. Peak Off-Peak
Rain	No	A.M. Peak Mid-day P.M. Peak Off-Peak	A.M. Peak Mid-day P.M. Peak Off-Peak
	Yes	A.M. Peak Mid-day P.M. Peak Off-Peak	A.M. Peak Mid-day P.M. Peak Off-Peak
Ice / Snow	No	A.M. Peak Mid-day P.M. Peak Off-Peak	A.M. Peak Mid-day P.M. Peak Off-Peak

Table A-2. Capacity Reductions Used to Represent Inclement Weather Conditions

Weather Conditions	Freeway Reduction	Arterial Reduction
Clear	None	None
Rain	-6%	-6%
Ice / Snow	-10%	-12%

[A-3] Transportation Research Board (2000). *Highway Capacity Manual*, Washington D.C.

impacts of the construction activities were simulated by reducing the baseline capacities for those roadway links identified as being within the construction zone. This reduction was conducted on an individual link-by-link basis, based on the initial number of roadway lanes, the number of lanes closed during construction, and the type of construction activity. The capacity reduction for each individual link included in the work zone was calculated by first subtracting out the number of lanes anticipated to be closed as a result of the construction activity. The capacities of the remaining lanes were then reduced based on the recommended capacity reduction factor from the highway capacity manual (based on the number of lanes in normal conditions and the type of construction activity). These capacity adjustments, for the lanes remaining open for the various projects, ranged from 75 percent of the original capacity for a two-lane facility undergoing resurfacing to 93 percent of the original capacity for a 3+ lane facility undergoing the addition of new lanes.

Additional Weather and Work Zone Mitigation Strategies

Additional weather and work zone mitigation strategies were deployed and analyzed in the appropriate Full Operations and ITS Deployment Scenarios containing the negative impacts of inclement weather and/or construction activity. These operations and ITS strategies are not currently included as available components for analysis within the IDAS tool. The software does have the capability, however, to deploy and analyze "generic," user-defined components. For these generic deployments, the user is provided the opportunity to specify the impacts of the components. The components are then analyzed identically to all other existing deployments in the scenario, providing the opportunity to analyze the impacts of the user-defined components side-by-side with existing IDAS components to capture the full synergistic impacts of all components. This capability was used to simulate the weather and work zone improvements on the network.

The impacts used in the analysis to represent weather and work zone mitigation strategies were based on the observed impacts from these types of deployments, where available, or the impact of similar operations and ITS components already available within IDAS. The impacts associated with the various weather and work zone mitigation strategies are presented in Table A-3.

Estimating the Annual Impact of the Full ITS Deployment Scenario in Cincinnati

Each of the 40 individual scenarios were analyzed separately to estimate the likely traffic conditions that would occur for each given time-of-day period with similar weather, construction activity and operations, and ITS deployment intensity. The results of the individual scenarios were then annualized by applying a weight to each scenario representing how many days a year that scenario would be anticipated to occur in a typical year.

The applied weights were developed by reviewing historical weather patterns and construction schedules. Historical weather data from the National Weather Service revealed that rain would be expected to occur on 17 percent of days annually, and measurable ice/snow precipitation occurs on an average of 18 days per year. A similar review of the construction

Table A-3. Impacts of Weather and Work Zone Mitigation Strategies

Strategy	Analysis Impact
Weather	
Weather ATIS/Road Weather Information Systems (RWIS)	ATIS information reaches 40 percent of regional travelers. Of those travelers receiving the information, 25 percent were able to save 6.3 percent of their travel time. (Based on existing IDAS ATIS methodology)
Work Zones	
Work Zone ATIS	ATIS information reaches an additional 10 percent of travelers using the work zone corridors. Of those travelers receiving the information, 25 percent were able to save 6.3 percent of their travel time. (Based on existing IDAS ATIS methodology)
Work Zone Incident Detection	15 percent reduction in incident duration in work zones. 15 percent reduction in fuel use rate and emissions rates in work zone. (Based on existing IDAS methodology and information from similar work zone deployment in Albuquerque, NM)
Lane Merging Applications	5 percent restoration of facility capacity in work zone. (Based on information from Midwest Smart Work Zone Initiative)
Alternative Route Management	10 percent increase in facility capacity for selected parallel arterial corridors serving as diversion routes. (Based on existing IDAS methodology for traffic signal coordination)
Alternative Work Hours	Reduction in the number of days (annually) with construction activity occuring in the peak hours, offset by lesser increase in the number of days with construction occurring in the nighttime period. (Based on information from Midwest Smart Work Zone Initiative)

schedules of the representative projects included in the typical construction season indicated that construction activity would be expected to occur on 53 percent of the days annually. The analysis further assumed that 45 percent of the rain days would occur during the construction season.

The number of days in a year was assumed to be 250, representing the number of weekdays in a year, not including significant holidays. The historical rates of occurrence for the various weather and construction activities were then applied to identify weights (in number of days per year) for the No Operations and ITS Deployment Scenarios. The weights for the Full Operations and ITS Deployment Scenarios were determined similarly, with the following exception. The weight representing number of days with construction activity in the peak periods was reduced to reflect the impact of alternative work scheduling strategies. The construction season for the off-peak scenarios was then extended to reflect the additional work shifted to the nighttime periods.

These identified weights were applied to each scenario and the resulting performance measures were summed for the No Operations and ITS Deployment and the Full Operations and ITS

Deployment Scenario. The summed results were then compared to identify the annual incremental benefits of the Operations and ITS strategies. Table A-4 presents the annualization rates that were applied in the analysis for each possible scenario, and shows how the proportion of days included in the annualization changes between the No Operations and ITS Deployment and Full Operations and ITS Deployment Scenarios. For the peak periods (AM, Mid-day, and PM) the proportion of days with road construction is reduced between the No Operations and ITS Deployment and Full Operations and ITS Deployment Scenarios to represent the impacts of alternative work hours. This table also shows the impact of shifting some of these roadwork activities to the off-peak periods.

Study Caveats

As documented in this appendix, the analysis of the three case study regions were conducted using similar, but not identical approaches and assumptions. Therefore, comparisons of major trends across the three regions are generally valid. Caution should be applied in any detailed cross-cutting analysis of specific impacts, however, due to model and approach differences that may have skewed results. The differences in the analysis approaches may make it difficult to discern if variations observed between the three regions are valid, or are a product of the analysis methodology. Some of the significant variations in the models and approaches which have the potential to impact results are documented below.

Tucson

The analysis of impacts in the Tucson region employed model data representing average daily travel in the year 2025. This region was the only one to use a future forecast of travel demand. The use of this future demand may result in the inflation of benefits, relative to other regions, since travel demand and related congestion is presumably greater than in the current year. The Tucson region was

Table A-4. Annualization Weights for Cincinnati

	Peak Periods (Includes AM, Mid-Day, and PM Peak Periods)				Off-Peak Periods			
	No Ops and ITS		Full Ops and ITS		No Ops and ITS		Full Ops and ITS	
Scenario	Days	%	Days	%	Days	%	Days	%
Clear	49	20%	66	26%	49	20%	32	13%
Rain	21	8%	24	10%	21	8%	18	7%
Ice/Snow	46	18%	46	18%	46	18%	46	18%
Clear with Roadwork	113	45%	96	38%	113	45%	130	52%
Rain with Roadwork	21	8%	18	7%	21	8%	24	10%
TOTAL	**250**	**100%**	**250**	**100%**	**250**	**100%**	**250**	**100%**

also the only region where a single daily forecast was used in the analysis. This unique characteristic may have the impact of decreased benefits relative to the other areas because the daily traffic model does not capture the impacts of increased congestion during the peak hours. The Tucson model was also not adjusted to specifically analyze variations in weather conditions or construction activity, as was performed in Cincinnati.

Cincinnati

The analysis of impacts in the Cincinnati region used model data representing travel conditions in 2003 for four separate periods—A.M. Peak Period, Mid-day Peak Period, P.M. Peak Period, and Off-Peak Period—with the sum of these periods equal to a single day. Further, additional models were constructed from these base models to represent traffic conditions during different combinations of weather conditions and road maintenance activity typifying a normal construction season. These additional models resulted in the analysis of ITS impacts during 20 unique traffic conditions, greatly adding sensitivity to the analysis compared to the other regions. Because the analysis produced increased benefit estimates for those alternatives representing inclement weather or construction activity, it is likely that the overall benefits estimated for Cincinnati are greater relative to the other areas. The analysis in Tucson and Seattle were not conducted with this sensitivity to weather conditions or construction activity, and would not have captured these additional benefits.

Seattle

The Seattle regional models used in the analysis represented travel demand in the year 2003 for three separate time periods: A.M. Peak Period, P.M. Peak Period, and the Off-Peak Period. The results from the Seattle analysis are, therefore, sensitive to the variations in impacts caused by peak period congestion. The Seattle models were not adjusted, however, to specifically analyze variations in weather conditions or construction activity, as was performed in Cincinnati.

In addition to the model differences noted above, other factors and parameters internal to the individual region's models may also affect the estimated impacts. Model characteristics such as the length of peak periods, volume-delay functions, and mode choice sensitivity may also promote differences in the analysis results.

Additional Caveats

Impacts of the operations and ITS deployments on incident-related delay were estimated in all three case study regions. The use of incident-related delay, non-recurring congestion, or travel time reliability as a measure of system performance is an emerging practice. As yet, there is often little consensus on the specific definitions of the performance measures used or the analysis methodologies applied in different studies. In this study, "incident-related delay" is estimated only for freeway facilities and represents the expected amount of delay occurring as a result of traffic incidents (crashes, stalls, and breakdowns). This performance measure is synonymous with the "travel time reliability" impact within the IDAS analysis methodology. Current incident data availability limits the application of this analysis methodology to only freeway facilities and does not currently allow for the estimation of incident-related delay for other surface roadways.

Other caveats, specific to the individual case study regions, are documented within the individual reports.

ITS Web Resources

ITS Joint Program Office:
http://www.its.dot.gov

ITS Cooperative Deployment Network:
http://www.nawgits.com/icdn

ITS Electronic Document Library (EDL):
http://www.its.dot.gov/itsweb/welcome.htm

ITS Professional Capacity Building Program:
http://www.pcb.its.dot.gov

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