The Status and Applicability of Intelligent Transportation Systems in Montana

Final Report

Prepared for the

STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT, AND TECHNOLOGY TRANSFER PROGRAM

In Cooperation with the U.S. Department of Transportation, Federal Highway Administration

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Implementation Statement

This study is sponsored by the Montana Department of Transportation (MDT) in cooperation with the Federal Highway Administration (FHWA). The major objective of this study is to develop a document that will serve both as an informational source concerning Intelligent Transportation Systems (ITS) in Montana and as a guide for MDT to use in planning ITS activities. Recommendations of this study will allow the development of an effective implementation plan for an ITS program based upon input from Montana stakeholders.

Disclaimer

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Montana Department of Transportation or the Federal Highway of Administration.

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Preface

It is a dark, cold winter morning. Sheri Inboden, an Emergency Medical Technician from Polaris, Montana, begins her daily journey of 45 miles to the Barrett Memorial Hospital in Dillon, Montana. While driving Highway 278, a snow squall suddenly develops. She is completely blinded by the blowing snow and comes to a stop. When the squall passes she realizes that she is in the opposite lane. Luckily, there were no other vehicles present. She reaches her destination, knowing the long winter will bring several, similar, stressful trips. Later that day, a victim of a severe car accident is brought to the hospital by ambulance. There is no telling how long the victim lay unconscious before he was found; it was obviously some time. Sheri knows that a delay of a few minutes in trauma treatment can result in paralysis or death for this young man (Inboden, 1995).

The December 17, 1995, Billings Gazette reported the following:

> "Corey L. Howell, 26, of Great Falls, died in that city's Montana Deaconess Medical Center on Friday, two days after he suffered head injuries in a one-vehicle accident. Howell's vehicle skidded off icy highway 200 near Rogers Pass, about 28 miles east of Lincoln, and overturned, said Mickey Nelson, the Lewis and Clark County coroner. Howell was ejected, but a passenger in the vehicle was not hurt . . . " (Billings Gazette, 1995a)
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> "An Oregon man died Thursday after the car he was in hit an elk on Interstate 90 west of Drummond. The Montana Highway Patrol identified the victim as Gerald Darby, 18. The patrol said he was returning from Jamestown College in Jamestown, N.D., when the accident occurred at 3:15 a.m. Thursday, about 8 ½ miles west of Drummond. The car struck an elk and rolled over . . . " (Billings Gazette, 1995a)
>
> "The Montana Highway Patrol was investigating a one-vehicle rollover near Pryor in which at least two people were injured late Saturday night. A Highway Patrol dispatcher said little was known about the accident Saturday because of the remote location of the wreck. There were multiple injuries, but the extent of those injuries were unknown, as were the exact number of people hurt . . . Officers and emergency crews had a tough time finding the wreck and also had to battle muddy road conditions on dirt roads to get to the accident. The Help Helicopter in Billings was unavailable for the accident because of poor weather conditions." (Billings Gazette, 1995b)

These examples describe transportation safety problems in Montana on a typical winter day. Are these safety problems just part of living in Montana, or can something be done to avoid them? Are the approximate 200 deaths and millions of dollars of property loss per year on Montana highways acceptable losses (Billings Gazette, 1995b)? Or, are there feasible technologies that can help Montanans in coping with their daily transportation problems?

Executive Summary

In an effort to cost effectively improve the safety and efficiency of Montana's transportation system, the Montana Department of Transportation (MDT) has taken a proactive approach to look at innovative solutions such as Intelligent Transportation Systems (ITS). The principal objective of this study was to accumulate information pertinent to ITS in Montana, which will aid in consolidating and focusing MDT's position on ITS. The following tasks worked toward this goal:

- Inform and identify concerns of Montana's transportation stakeholders;
- Identify needs and potential benefits of ITS in Montana;
- Identify existing systems and related activities in Montana and the Nation;
- Identify potential systems for Montana;
- Identify potential funding sources; and
- Develop a Scope of Work for Phase II.

Montana's transportation stakeholders were contacted to inform them of ITS, discuss ITS activities in Montana, and receive feedback concerning their views and concerns about ITS. Both public and private organizations at state, regional, and local levels were involved. In all, 35 groups were contacted by meetings, mail, and phone. The groups most liked technologies which improve safety such as collision warning and construction zone safety improvements. Most groups were in favor of a statewide ITS deployment plan. However, they had many concerns. The biggest concerns dealt with funding and cost issues.

Nationally, the benefits of Intelligent Transportation Systems have been identified as follows:

- Improve safety;
- Reduce congestion;
- Improve mobility;
- Reduce environmental impacts;
- Increase energy efficiency; and
- Improve economic production.

All of these areas are of concern to Montana's transportation system. However, the primary benefit to Montana is improved safety. In Montana, there are approximately 200 deaths caused by traffic accidents each year. The Federal Highway Administration indicates that with one additional second of advanced driver warning, 90% of collisions could be avoided.

In addition to preventing accidents, ITS could save lives by improving medical response time to traffic accidents. In non-metropolitan areas of Montana, in 1992, it took an average of 12.47 minutes after an accident to notify the emergency medical services

(EMS). A Mayday system could cut this time to seconds. In addition, response time could be cut by better managing emergency vehicle fleets through route guidance and advanced fleet management techniques.

A benefit to commercial vehicle operations is the cost savings to be realized by avoiding stops at weigh stations. The excess cost to the motor carrier for stopping at weigh stations was found to be approximately $4.40, on average. This cost includes operating, fuel, and delay costs, and tire and brake wear. The actual cost to a specific truck depends on many variables including scale geometry, volume of truck traffic, scale operator technique, driver technique, truck type and load.

The application of ITS technology is not new to Montana. Existing and planned ITS projects in Montana include:

- SCAN Weather Monitoring System, which consists of weather stations that monitor temperature, surface road condition, and humidity at strategic locations around the State. The data is used by MDT to more efficiently dispatch snow removal equipment, monitor highway conditions in general and provide the public with constantly updated road condition information.

- Advanced Traffic Control is used in metropolitan areas around the state to coordinate traffic signal timing and detect traffic accidents.

- Data Collection is used by MDT for planning and design. MDT currently operates 65 permanent and approximately 85 portable automatic traffic data collection sites to measure traffic volume, axle configurations and speed.

- Weigh-in-Motion (WIM) is also beginning to be used by MDT to collect data on commercial vehicle counts, gross vehicle and axle weight, axle spacing and other vehicle category data. This data is collected while commercial vehicles are operating at mainline speeds. The seventh WIM site will become operational by the end of 1996.

- Heavy-Vehicle Electronic License Plate (H.E.L.P.) Inc. is an industry leader in electronic clearance technology. H.E.L.P. Inc., in partnership with Lockheed-Martin and the state of California, operate seven automated weigh stations in California, allowing commercial carriers which join H.E.L.P. Inc. to be checked and cleared while traveling at mainline speeds. Montana and ten other states are H.E.L.P. members. For its membership, MDT receives design and engineering support and training from H.E.L.P. staff and Lockheed-Martin.

- Traveler Information Booths are being developed by the Montana Tourism and Recreation Initiative. Travelers will be able to use these touch screen booths to access information on recreation facilities, hotels, trails, rivers, lakes, construction zones, weather and transit. The initiative will initially place 10 booths around the State in key locations, such as rest areas.

- Ride Matching is being reviewed by local officials in the Bitterroot Valley.

- Five Onboard Computers for Law Enforcement Vehicles are being tested by the Department of Justice. These computers will allow enforcement personnel to quickly run license plate checks and access other important information.

- MDT is a member of ITS America and participates in the Advanced Rural Transportation Systems Committee (ARTS). MDT is also an outreach member of the Rockwell architecture group and the National Automated Highway System Consortium (NAHSC).

There are many ITS technologies that are applicable to Montana. Below is a list of potential ITS technologies identified in this report.

- Data Collection
- Automated Inspection
- Collision Warning/Avoidance
- In-Vehicle Signing
- Animal Collision
- Slow-moving Vehicle Warning
- Slippery Conditions Warning
- Intersection Collision Warning
- Active Logo Signing System
- Intermodal Transfer Facilities
- Robotics in Construction & Maintenance
- Electronic Clearance
- Mayday
- Vision Enhancement
- Work Zone Traffic Control
- Emissions Testing and Mitigation
- Incident Management
- Safe Speed System
- Advanced Tourist Information
- In-Vehicle Navigation
- Advanced Public Transit Systems

ITS projects are eligible for funding from many sources such as Interstate Maintenance funds, National Highway funds, and Surface Transportation Program funds. Two major points are made with respect to funding ITS projects. First, ITS projects must compete with any other transportation improvement project based on costs and benefits. Second, because of the nature of ITS projects, they are generally less expensive when included in traditional road construction projects.

Recommendations for the success of the ITS program are summarized as follows:

1) Develop an ITS strategic plan for Montana. In general stakeholders want to see a state plan for the deployment of ITS. In addition, TranPlan 21 calls for MDT to develop a strategic ITS plan.

2) Organize and staff an ITS office. A program coordinator is important to the success of the program. This person can coordinate ITS activities within MDT and other agencies. In addition to a program coordinator, it is recommended that MDT involve all interested parties from the beginning. This will help to pool resources and eliminate jurisdictional problems down the road.

3) Education and promotion of ITS at the community and state levels. A good outreach program will ensure buy-in to the ITS program from transportation planners, the traveling public, and other important groups.

4) Stay abreast with privacy, liability, reliability and other institutional issues. There are many problems with ITS already foreseen by the USDOT and ITS America. Various groups are already working on solutions to these problems. As they develop solutions, MDT should review these solutions and, where appropriate, incorporate them into Montana's ITS program.

5) Ensure reliability and quality of investment. Investing in a system which yields poor results is not cost effective and provides a poor image of the ITS program to the public and transportation planners. Quality can be ensured by:

- Having an ITS coordinator knowledgeable of ITS products;
- Ensuring that products conform to national standards; and
- Developing specifications and standards where they do not exist nationally.

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1 INTRODUCTION

In 1956, the United States established the Highway Trust Fund, which has led to the development of the most extensive transportation system in the world. The U.S. system of interstate highways and subsystem components are unsurpassed.

Despite these developments, congestion and safety problems, stemming from the explosive growth of VMT (vehicle miles of travel), continue to plague local, state and federal governments. As continued expansion of the road system becomes unfeasible and too costly, transportation professionals have turned to computers and electronics to increase capacity and safety of transportation systems.

The U.S. and the other developed countries have embarked on a program of Intelligent Transportation Systems (ITS) to alleviate congestion and safety problems. As expected, urban congestion received attention first, leading many to believe that ITS was not applicable to rural transportation. States with large urban transportation centers (California, Texas, Minnesota, etc.) have made significant progress in establishing and developing ITS programs. Rural states such as Montana and Wyoming had not felt the expediency to develop ITS programs.

Montana, however, does realize that ITS may have applications to its transportation problems, and has initiated action to explore ITS. In early 1995, the Montana Department of Transportation entered into agreement with the Western Transportation Institute of Montana State University to perform a preliminary study to assess the Status and Applicability of Intelligent Transportation Systems in Montana. The following sections contain the findings of the study.

1.1 Needs and Benefits of ITS

In the last 30 years, the national vehicle miles traveled has doubled from one trillion to two trillion. New road construction has not been able to keep up with this dramatic growth. The resulting congestion is estimated to cost the nation $100 billion annually. In addition, there were 41,000 deaths and 5,000,000 injuries in the United States resulting from traffic accidents during 1991. The traffic related deaths are expected to increase to 80,000 in the year 2010. To alleviate these problems and keep costs in check, innovative solutions and the incorporation of advanced technologies, such as ITS, into traditional infrastructure are required (Diebold Institute, 1995).

The most important issue in MDT's statewide plan was safety. In Montana, in 1994, there were 202 deaths related to traffic accidents (USDOT, 1993a). It is estimated that if the driver were warned of the impending collision one half second earlier, 50% of rear-end collisions and cross road collisions, and 30% of head-on collisions would be avoided. If one extra second were given to the driver 90% of all accidents would be avoided. It is expected that ITS will save 11,500 lives, 442,000 injuries and $22 billion in property damage nationally by 2010 (Diebold Institute, 1995).

In addition to preventing accidents, ITS could save lives by improving medical response to traffic accidents. In Montana, in 1992, it took an average of 12.47 minutes after an accident to notify the emergency medical services (EMS), 15.77 minutes more for EMS to arrive, and an additional 39.7 minutes to transport victims to the hospital (USDOT, 1993a). A Mayday system could lower the 12.47 minutes to seconds. In addition, response time could be decreased by better managing emergency vehicle fleets through route guidance and advanced fleet management techniques.

Congestion may not seem to be a rural transportation concern. However, TranPlan 21 identifies approximately 305 miles of roadway which are currently operating at a level of service (LOS) D or worse. Furthermore, TranPlan 21 indicates a continual decline in LOS through the year 2015, with an estimated 467 miles of roadway operating at an LOS D or worse (Dye Management Group, Inc., 1995). "Level of service" is a measure of operating conditions within a traffic stream as perceived by the users, ranging from A to F. Level of service A describes a free flow with individual vehicles being unaffected by the presence of other vehicles. Level of service E represents a roadway operating at capacity, while level of service F defines breakdown of flow conditions. While highway safety is MDT's first priority, congestion mitigation is important as well. It is estimated that automating a highway system, the number of lanes being the same, will increase capacity by 200 to 300%. Also, Montana is growing and some metropolitan areas in the State are having problems with congestion. In metropolitan areas, 20% use of dynamic route guidance would reduce delay time by an estimated 20%. Dynamic route guidance would give vehicles information enabling them to avoid congested areas (Diebold Institute, 1995).

Environmental effects of pollution and energy use will be reduced by ITS. The reduction in congestion, travel times, and stops and starts, will affect these environmental impacts. It is estimated that metropolitan areas which implement advanced traffic management techniques will see a 10% reduction in vehicle emissions and a 12% reduction in fuel consumption (Diebold Institute, 1995).

Overall, ITS will have a positive economic benefit. Most ITS are expected to see a 10:1 return. In addition, the increased efficiency in the transportation of goods will have a strong effect on the economy (Diebold Institute, 1995).

1.2 General Background

In December of 1991, Congress passed the Intermodal Surface Transportation Efficiency Act (ISTEA). Within ISTEA there is a provision to establish an Intelligent Vehicle Highway System (IVHS) program. The IVHS concept has since been broadened to

Intelligent Transportation Systems (ITS) to match the intermodal theme of ISTEA. The ISTEA Bill included the following provisions which launched ITS:

- Appropriated approximately $660 million in federal research funding for a six-year period;
- Mandated that the U.S. Department of Transportation develop a National Program Plan;
- Encouraged states to develop state ITS plans;
- Promoted compatible standards and protocols within ITS;
- Established an information clearinghouse; and
- Established evaluation guidelines for operational tests (USDOT, 1995a).

The goals and objectives of Intelligent Transportation Systems are to use advanced technologies to accomplish the following:

- Improve Safety;
- Reduce Congestion;
- Improve Mobility;
- Reduce Environmental Impacts;
- Increase Energy Efficiency; and
- Improve Economic Productivity.

Several federally sponsored operational tests of such systems have been implemented at numerous locations within the United States. An example is the Storm Warning project in southeastern Idaho on I-84, where blowing dust and snow frequently strand motorists (USDOT, 1995b). These federally funded tests will aid in future deployment of similar systems by identifying problems, comparing optional system setups and providing preliminary cost/benefit data.

A National Strategic Plan was submitted to Congress, as required, one year after ISTEA became effective (USDOT, 1994a). The plan included the goals, milestones and objectives of the IVHS program and has been updated to highlight the multimodal theme of ITS. The national plan also mandates the development of a national architecture.

Several states, as well as Canada, have already completed ITS plans. Many of these states have rural problems similar to Montana, such as Colorado, Minnesota, Oregon, and Washington. An ITS plan establishes the direction and policy which a state will use to address its future involvement in adopting and promoting ITS technologies.

1.3 ITS America

ITS America, founded as IVHS America in 1990, is a national organization with representation from local, state and federal agencies, the private sector and academia. It is providing leadership and guidance in the development of ITS technologies. ITS America has also set up a national information clearinghouse and is involved in the promotion and development of standards. ITS America is an official advisory body to the USDOT and has aided in the development of the national program plan and the national architecture. It has also developed a network of support and information dissemination through state chapters, annual meetings and a world wide web page on the Internet (http://www.itsa.org/).

1.4 National Architecture (USDOT, 1994b; USDOT 1995c)

USDOT, with the help of ITS America, is currently developing a National ITS Architecture to guide the nation as it develops and deploys ITS. The national ITS architecture will define different potential services, analyze the information links between transportation components and analyze the data needs of these links. The system architecture is not hardware design or system component design. A correlation can be made to the home stereo system. The home stereo architecture only defines the function of components and the interaction with other components, leaving decisions of component design up to the manufacturer. The ITS Architecture will aid in deciding where national standards are necessary to accomplish the goals of ITS and determine what can be done to encourage each state to implement ITS technologies. However, the ITS national architecture will leave the primary decisions regarding the selection of which ITS user services to deploy to the state, regional and local agencies; transit and commercial fleet operators; consumers; and the motoring public. This flexibility is accomplished by an open architecture which does not require all ITS user services to be deployed. Any combination of ITS user services is possible, and will yield optimal use of shared communication resources with the architecture design. USDOT, through Rockwell International and Loral, Inc., is currently in the middle of Phase II of their two-phase project to develop a national ITS architecture plan. This phase will be completed, in July 1996, with the production of a plan to implement the ITS national architecture.

1.5 Montana Department of Transportation Involvement

The Montana Department of Transportation (MDT) has deployed several ITS related projects as a part of standard highway and/or maintenance programs in recent years. A summary of these projects can be found in Sections 4 and 5 of this report. In order to consolidate MDT's focus concerning ITS, a two-phase planning effort was originally devised in the fall of 1994. The first phase encompassed the development of this report. After this project is completed, should MDT decide to pursue an ITS program, Phase II will follow with the development of a long term ITS State Plan for Montana. The target date for the completion of Phase II is six to nine months after a contract is awarded.

The Montana Department of Transportation is a member of ITS America and participates in the Advanced Rural Transportation Systems Committee (ARTS). In addition, MDT is an outreach member of the Rockwell architecture group and the National Automated Highway System Consortium (NAHSC) and will soon be a member of the Rocky Mountain Chapter of ITS.

TranPlan 21

TranPlan 21, a twenty-year plan for the State with buy-in from all levels within MDT, discusses the development of ITS in Montana under Policy Goal D (Dye Management Group, Inc., 1995). This policy, as outlined in TranPlan 21, directs the MDT to take full advantage of the efficiencies to be gained from these technologies as cost-effective methods for getting the most out of the existing system. The plan makes the following recommendations:

Action D.1. Develop MDT-ITS strategic and tactical plan
- -basis for evaluating and deploying ITS
- -make sure to consider the following systems
  1. Run-off-the-road collision avoidance
  2. Commercial Vehicle applications (electronic clearance)

Action D.2. Encourage metropolitan planning organizations to include consideration of ITS in their long range plans.

1.6 Western Transportation Institute

A resource of ITS is the Western Transportation Institute (WTI) for advanced rural transportation technology, research and education. WTI is located in the Civil Engineering Department of Montana State University (MSU), and is funded through a cooperative agreement between MDT, Caltrans and MSU. The goals and objectives of WTI, though focused in rural concerns, are basically the same as ITS. WTI was a leader in establishing the ARTS committee, and many other national rural ITS programs. WTI is also a member of the Rockwell International System Architecture team.

1.7 Goals of This Study

This study was performed to determine the status and applicability of ITS technologies in Montana. The tasks included: communication with stakeholders, review of appropriate literature, development of a cost per stop for commercial vehicles, development of a Scope of Work for Phase II and the development of this report. Each of these tasks is briefly discussed below.

Meetings were held with people and organizations across the State that had a direct interest in transportation. During these meetings short presentations were given to explain ITS, followed by discussions of, and reactions to, ITS. In addition, a brief questionnaire was distributed. Other stakeholders who were unavailable were sent a package containing a letter explaining the study, some graphics explaining the different ITS technologies, an ITS brochure and the questionnaire mentioned above. After mailing the packet, follow-up contacts were made by phone to assure feedback. A Summary of this task can be found in Section 3 of this report.

During Phase I, relevant ITS literature was reviewed, including ITS plans for other states, ITS demonstration projects, progress on the national architecture and other available informational documents.

The cost per stop of commercial vehicles at weigh stations can be used to quantify any savings for bypassing a Motor Carrier Services (MCS) scale facility through the deployment of ITS.

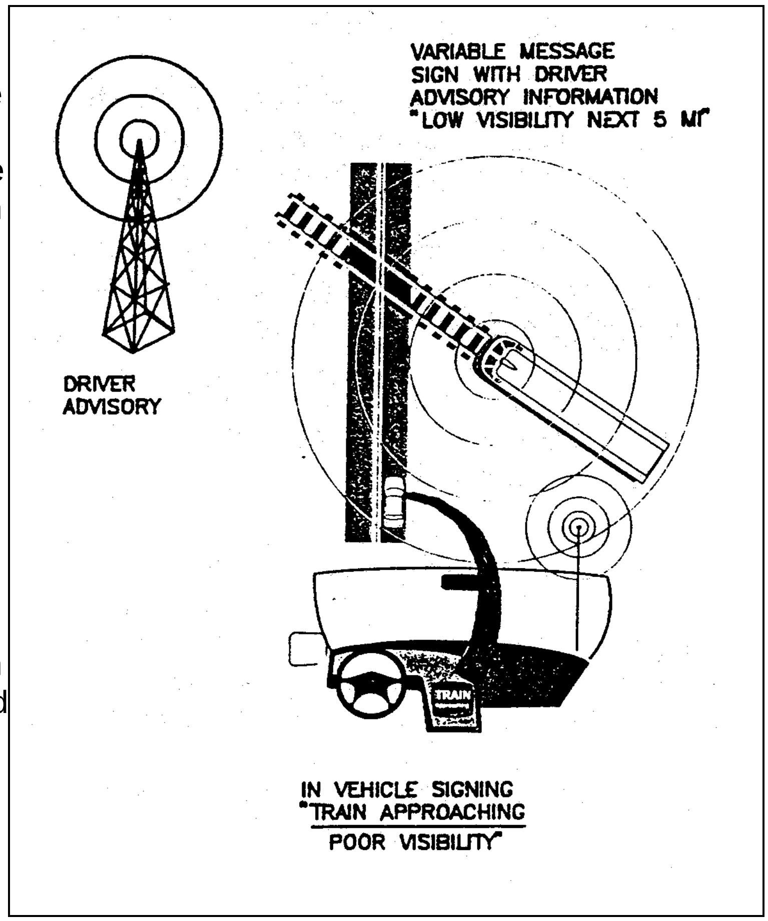
The purpose of the scope of work for phase II (Section 11) is to aid in the development of a request for proposal (RFP) for the development of a statewide ITS strategic deployment plan.

2 What is ITS?

To make ITS easier to understand, the USDOT and ITS America have classified the different Intelligent Transportation Systems into 29 areas known as user services (USDOT, 1995a), which are further grouped into seven major areas. In addition to these seven areas, this project has added an eighth area for potential services which do not readily fall into the 29 user services defined by USDOT. The following describes the different potential ITS services.

2.1 Travel and Transportation Management

2.1.1 En-Route Driver Information



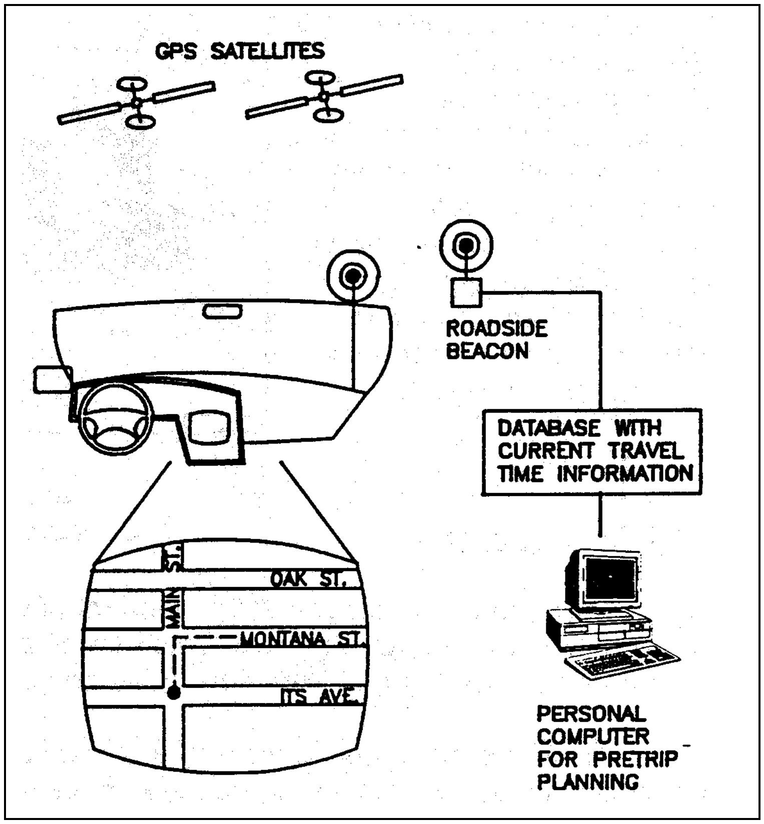
En-route driver information can be divided into two main areas, namely, driver advisory and in-vehicle signing. Both areas are depicted in Figure 1. Driver advisory involves the transmittal of real-time information on road conditions, traffic, incidents, construction, transit schedules and weather conditions to the drivers of personal, commercial and transit vehicles. This information allows the driver to choose the best route and mode of transportation, while en-route to a given destination. A driver advisory could be as simple as Highway Advisory Radio (HAR).

In-vehicle signing conveys the same types of information that are on physical road signs, but is transmitted to, and displayed inside, the vehicle. The driver is informed by a visual display or audio transmission depending on the system design. This service is dynamic in that the message can be changed easily. For example “ice on bridge” warning would only be active when sensors on the bridge indicate the presence of ice.

Dynamic information could also be given to the driver via a variable message sign. A safe speed system is an example of a use for variable message sign. This system uses sensors to monitor road surface conditions and weigh and classify vehicles (e.g., commercial vehicles before long, steep, downhill grades). A safe speed for the conditions is then calculated for the vehicle and relayed to the driver by a variable message sign.

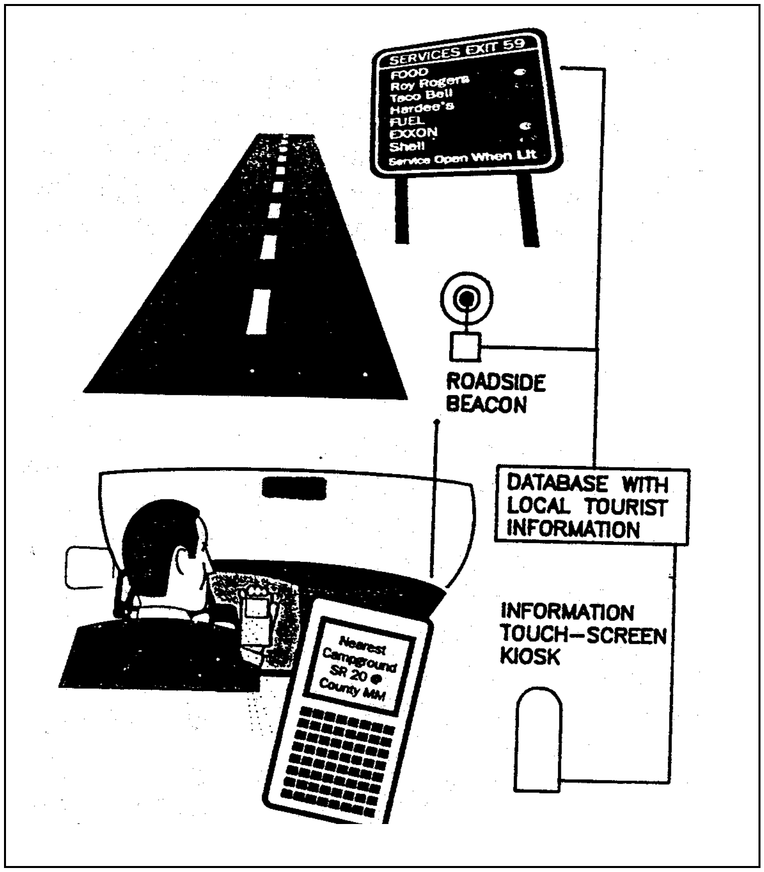
2.1.2 Route Guidance

Route guidance, depicted in Figure 2, will give travelers step by step directions on the best way to reach a particular destination. Earlier systems were based on static information. More advanced systems, however, will be updated with real-time transit schedules, traffic conditions and road closures. Safety would be improved if, for instance, tourists in unfamiliar areas were able to concentrate on driving instead of navigation. The transportation system would be better utilized by routing drivers away from congested areas. This system could consist of an in-vehicle device for any type of driver, or a hand held device for pedestrians, bicyclists and transit users.



2.1.3 Traveler Services Information

Traveler services information provides a "yellow pages" directory of services and facilities to the traveler. These services and facilities will include food, lodging, parking, auto repairs, hospitals and police. In addition, the information will provide operating hours, locations, phone numbers and availability. As shown in Figure 3, travelers will be able to access this information from their vehicle, home, office, and at kiosks located at rest areas and other convenient locations. This system could allow for an interactive connection between users and providers for reservation or information requests.



2.1.4 Traffic Control

Traffic control manages the movement of traffic, giving priority to emergency and transit or high occupancy vehicles. This service also improves safety and mobility of pedestrians and bicyclists. There are three components to traffic control.

The first is advanced surveillance of transportation systems and traffic flow. This activity can be accomplished through loop detectors, cameras and other sensors in the road. Surveillance also includes direct communication with emergency 911 centers and transit authorities to move those vehicles through the system quickly.

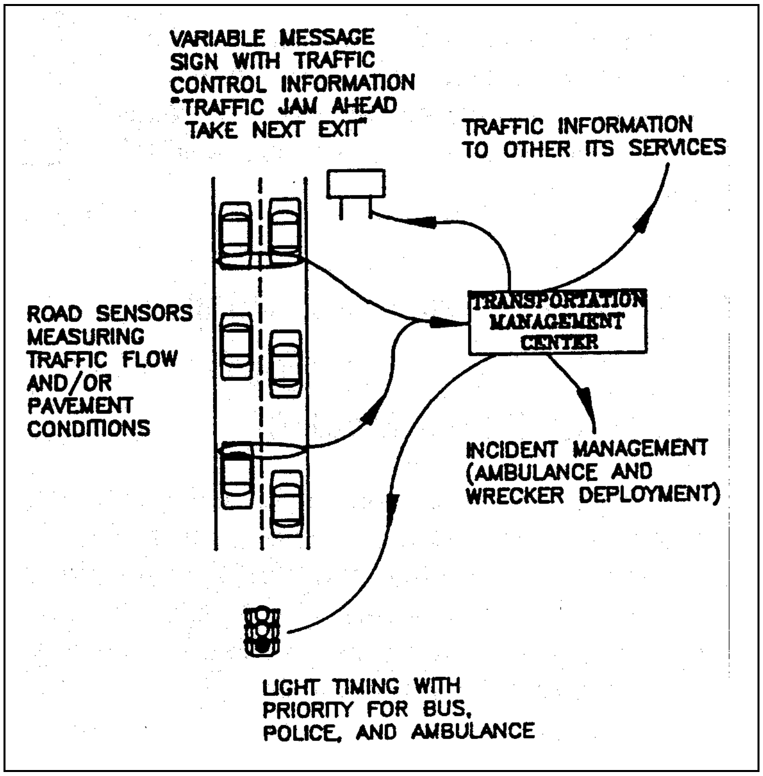
The second aspect is the analysis of traffic data. At the traffic control center the incoming surveillance information must be analyzed to identify the best traffic signal and ramp metering controls. When the analysis is complete, these controls are relayed to the roadside infrastructure, which comprises the third and final component of traffic control.

Roadside infrastructure could include variable message signs, signal controllers and/or radio communication to the vehicles (HAR or in-vehicle signing). Responses could be automated by computers, done manually, or a combination of both. The real-time traffic information collected by this service can also be used by other services such as dynamic route guidance.

Another aspect of traffic control is work zone traffic control. Work zone traffic control uses advanced technologies to improve safety in construction zones. In order to improve safety, such systems could include the use of variable message signs, vehicle sensors and advanced warning devices for the driver and construction worker.

2.1.5 Incident Management

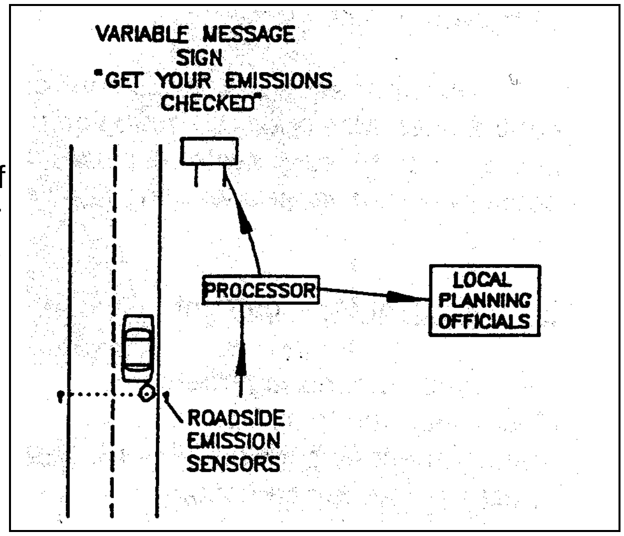
Incident management, closely married to traffic management as shown in Figure 4, uses advanced detection capabilities to detect and confirm incidents. It also coordinates the different agencies, such as transportation and public safety officials, towing and recovery industry and others involved in incident response. Types of incidents include planned and unplanned occurrences, such as:



- Road construction and maintenance;
- Road closures due to weather;
- Sporting or other community events which put strain on the existing traffic system;
- Vehicle accidents; and
- Failure of existing traffic infrastructure.

2.1.6 Emissions Testing and Mitigation

Emissions testing, shown in Figure 5, will monitor emissions using advanced testing systems to locate highly polluted areas and reroute traffic to alleviate the pollution. Another aspect of this service involves the monitoring of individual vehicles through roadside sensors or in-vehicle devices to identify vehicles which are emitting levels of emissions above state, regional or local regulations. This allows fleet managers to detect problem vehicles and remedy the situation. Planning and operating agencies can use this information to implement and evaluate various pollution control agencies.



2.2 Travel Demand Management

2.2.1 Pre-Trip Travel Information

This service provides the traveler with information for selecting the best transportation mode, route and departure time. The information could be accessed from home, work or other major sites where trips originate. Additional information would include transit routes, fares and schedules, ride matching, accidents, road closures, travel times, parking conditions, weather and event schedules, as well as bus, airline, and rental car information.

2.2.2 Ride Matching and Reservations

As roadways become more congested and funds become less available, the need arises to look at ways to move people more efficiently. This service makes it easier to use transportation modes other than the single occupancy vehicle. A ride matching system will match riders with drivers for car pooling. This system can be made more efficient through the use of computer matching and speech recognition. Users in their homes, offices or other locations can access the system by phone or computer. This service can also assist public transit, paratransit and van/carpoolers with vehicle assignments.

2.2.3 Demand Management and Operations

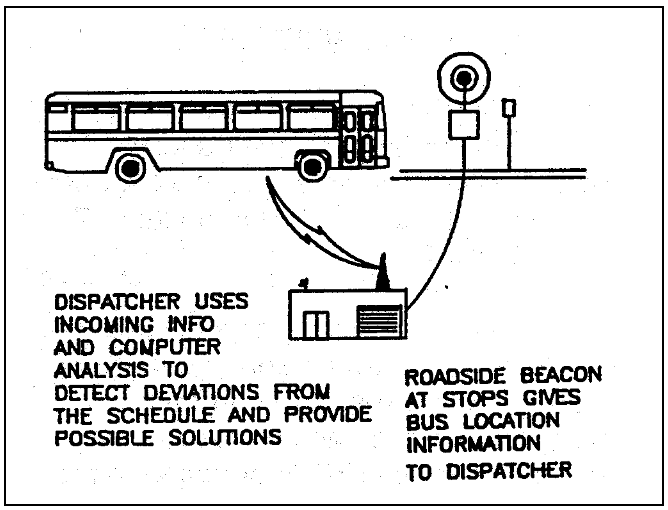
Demand management involves setting and supporting policies which reduce the number of single occupancy vehicles through incentives and disincentives. Such policies encourage people to use alternative modes (transit, car pool, bicycle, pedestrian), travel during non-peak periods or not take the trip at all. Policies could include:

- Increasing tolls and parking fees;
- Decreasing transit fees;
- Offering incentives for employees to car pool; and
- Offering incentives to businesses who allow employees to telecommute or flex their hours increasing travel during non-peak hours.

2.3 Public Transportation Operations

2.3.1 Public Transportation Management

Public Transportation Management uses advanced technologies to automate the operations, planning and management functions of public transit systems. Some possible elements of this service are shown in Figure 6. Computers will analyze and record real-time data on vehicle and facility status, traffic congestion, passenger loading, bus running times and mileage accumulated. The computer will identify deviations from the schedule and other potential problems and provide possible solutions. This information can be used to plan routes, manage personnel and equipment, improve service and facilitate administrative reporting.



2.3.2 En-Route Transit Information

This service provides travelers with transit information after they begin their trip. Real-time travel information on the bus or at stops can be used by riders to make better transfer decisions. This information could also be used through hand-held devices, in personal vehicles for park and ride access, or by people on foot. This service could be a component of en-route driver information or pre-trip planning.

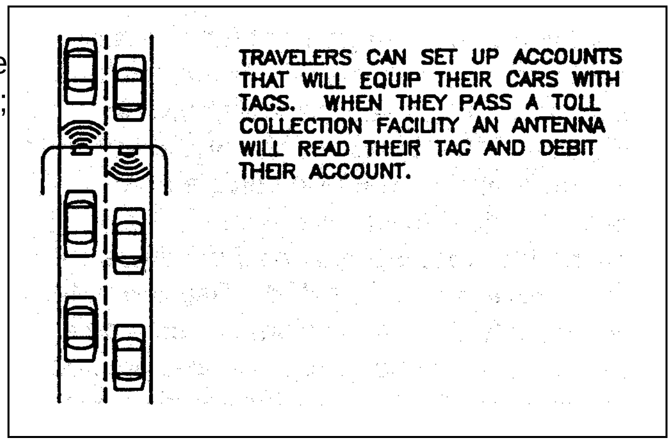
2.3.3 Personalized Public Transit

Personalized Public Transit (PPT) implements a Dial-A-Ride type of system, providing on-demand, door to door service. Route deviation schemes, where vehicles would leave a fixed route for a short distance to pick up or discharge passengers, are another way of improving transit service. In addition, PPT could expand transit coverage for less populated areas.

2.3.4 Public Travel Security

Safety and security for travelers can be increased in and around bus stops and transit vehicles by using security cameras to monitor parking lots. Automatically or manually activated alarms can be installed also.

2.4 Electronic Payment



Travelers can pay tolls for use of transportation facilities electronically. There are two places this technology can be used; toll booths, shown in Figure 7, and public transit.

Instead of waiting at a toll booth, a vehicle will pass an antenna at mainline speeds. An inexpensive on-board transponder will communicate the necessary transaction information to the antenna within a few seconds. This technology decreases travel time, improves safety by maintaining traffic flow, decreases pollution emitted by vehicles waiting in the queue at toll stations and reduces the need for toll facilities. Electronic toll collection can be more dynamic in that fees can be modified to reflect the demand. Higher prices during rush hour may motivate people to travel at different times. With some set-ups of this service, a monthly printout of tolls incurred can be provided to the driver. After reviewing this printout, a traveler may choose to take an alternate route or type of transportation, or not make the trip at all.

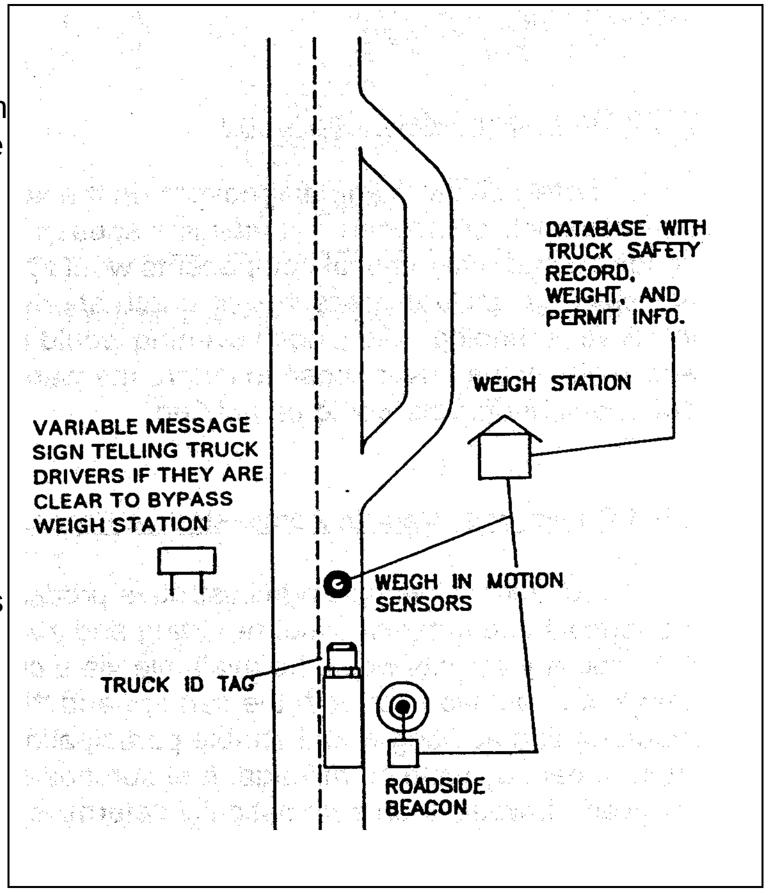
Pedestrians could use “smart cards” when they use public transit. Smart cards are much like credit/debit cards, only account information is stored on the card instead of a central database. The cards contain microchips inside which store account information. A smart card user can add money to their account with a type of automated teller machine.

When a person enters a public transit vehicle, they would swipe their smart card through the card reader on the bus. The fare would be automatically deducted from their account. This would make the process faster and eliminate the need for exact change.

2.5 Commercial Vehicle Operations

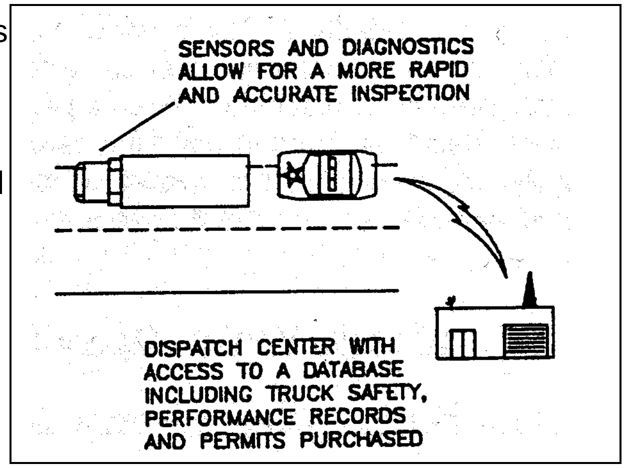
2.5.1 Commercial Vehicle Electronic Clearance

Electronic clearance is depicted in Figure 8. Commercial drivers with good driving records can subscribe to the electronic clearance system allowing them to bypass weigh stations. This system saves time and money for operations and frees up time for law enforcement officials to concentrate on the problem vehicles. Weigh-In-Motion (WIM) allows vehicles to be weighed at mainline speeds. Transponder-equipped vehicles will send their identification number to the weigh station. The weigh station can then access a database with the vehicle's safety record and credentials. If the vehicle is clear to go, the weigh station will signal them to bypass the station by either a variable message sign or a signal sent to the transponder.



2.5.2 Automated Roadside Safety Inspection

There are two major components to this service, depicted in Figure 9. The first is roadside access to real-time information regarding safety and performance records of carriers, drivers and vehicles. This service will aid enforcement officials in deciding which vehicles and drivers should be stopped for an inspection. The second aspect is the automation of as many items of an inspection as possible. Sensors and diagnostics would allow for a faster and more accurate inspection of vehicle components.



2.5.3 On-Board Safety Monitoring

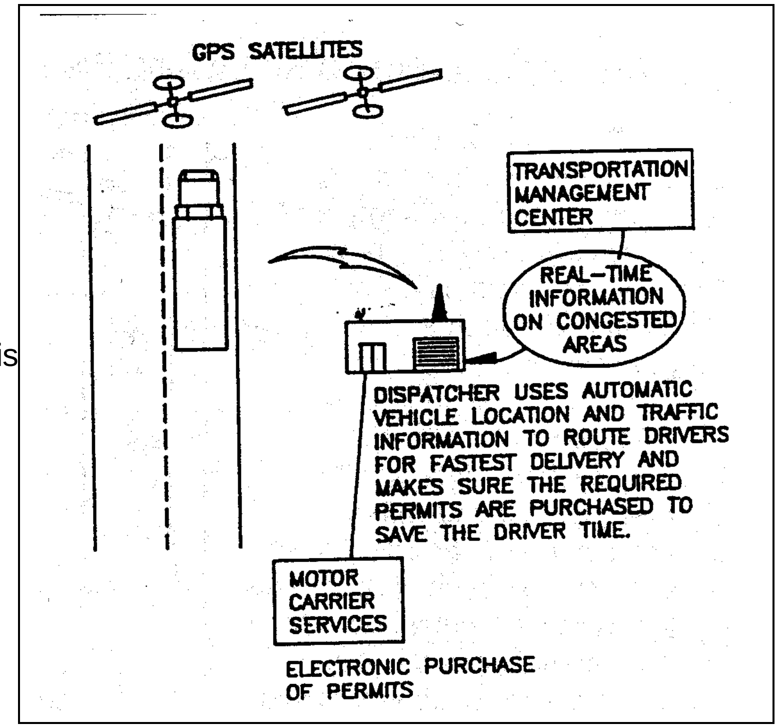
Safety sensors and diagnostics on the vehicle would allow for monitoring of critical vehicle components at mainline speeds. Brakes, tires, lights, cargo, the driver's condition and other critical components would be monitored. Driver monitoring is envisioned to include measures of length of driving time and alertness using non-intrusive technology. Advanced warning would be relayed to the driver to prevent accidents. If the driver chose to ignore the warning information, the carrier and/or enforcement officials would be notified.

2.5.4 Commercial Vehicle Administrative Process

Commercial vehicle administrative process provides electronic purchase of credentials and automatic fuel reporting and auditing. Electronic purchasing of annual or temporary permits would be available via a computer link. This procedure saves time and paper work for both the carriers and the state. Automated fuel mileage reporting and auditing would enable participating interstate carriers to electronically capture data by state on mileage, fuel purchased, and the specific trip and vehicle involved. It would then automatically determine the mileage traveled and fuel purchased in each state, for use by the carrier in reporting fuel tax and registration to the perspective states.

2.5.6 Freight Mobility

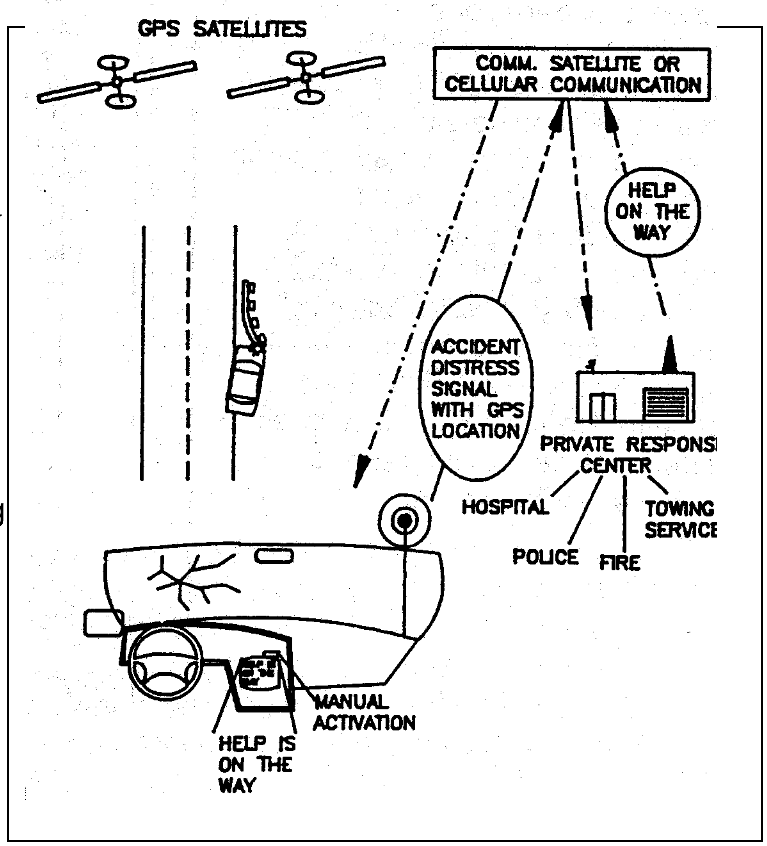
Freight mobility, depicted in Figure 10, provides communication between drivers, dispatchers and intermodal transportation providers. Real-time traffic information and vehicle location is used by dispatchers to better manage their fleet. A load of cargo could be transferred between different drivers at a convenient meeting point. All this information allows for faster, more efficient routing of goods by the carrier. In addition to time savings, other benefits are also gained, such as allowing drivers to spend less nights away from home.



2.6 Emergency Management

2.6.1 Emergency Notification and Personal Security

This service allows personal vehicles to notify emergency response centers of accidents from remote areas. This service could utilize call boxes at the roadside or a Mayday system.



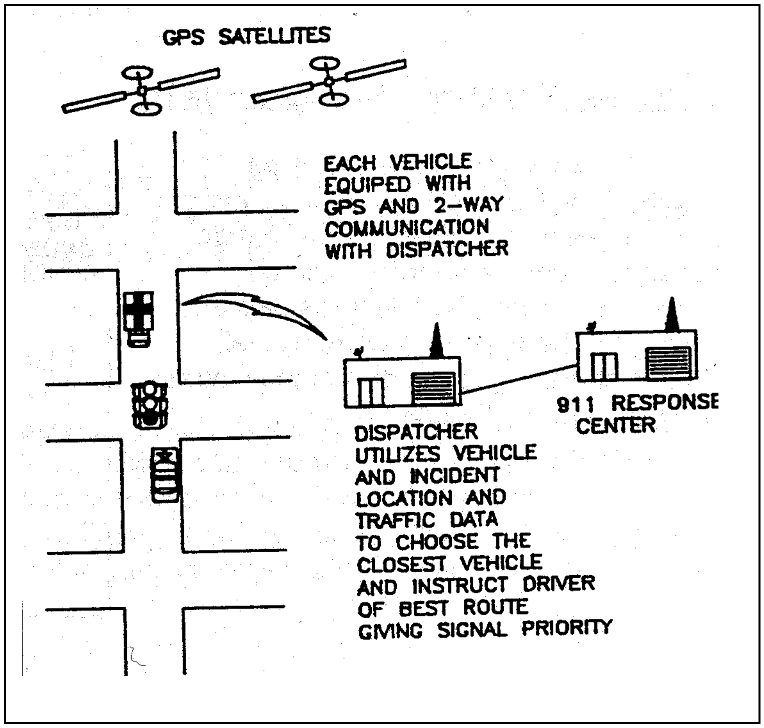
When activated, the Mayday system would send a distress signal along with information on the accident to an emergency response center. The system would be equipped with the Global Positioning System (GPS) so the GPS location could be sent along with the Mayday message. The system could be used to report serious accidents, crimes, or vehicle breakdowns and could be activated manually or automatically when sensors on the vehicle indicated a crash. The Mayday message is sent via cellular phone or satellite.

This system would decrease the response time for emergency vehicles responding to accidents. This increased response speed is accomplished both by reducing the time between an accident and notification of the proper authorities, as well as by eliminating the uncertainty of incident location.

In rural areas it takes an average of ten minutes after an accident to notify the authorities (USDOT, 1993a). The Mayday system may lower this time to a few seconds. Ten minutes could mean the difference between life and death in some situations. Figure 11 depicts the Mayday system.

2.6.2 Emergency Vehicle Management

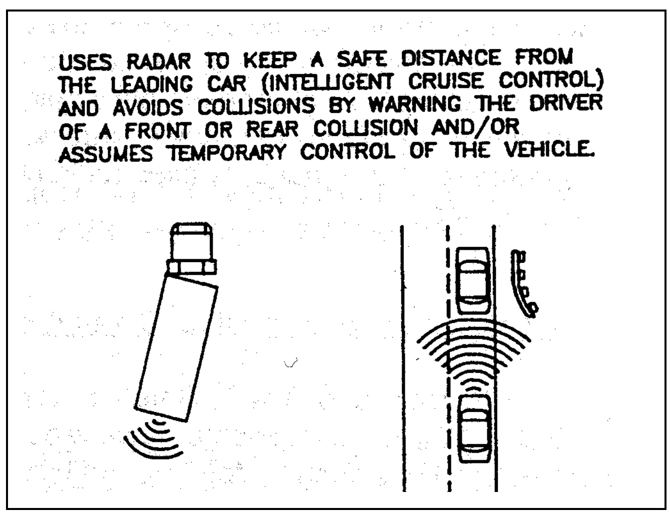
Emergency vehicle dispatchers will receive incoming information on traffic congestion, vehicle locations and incident locations to choose the closest emergency vehicle and instruct the driver as to the best route to take. Also, the dispatcher can be connected to a traffic management center so they can give signal priority to these response vehicles (Figure 12).



2.7 Advanced Vehicle Control and Safety Systems

2.7.1 Longitudinal Collision Warning/Avoidance

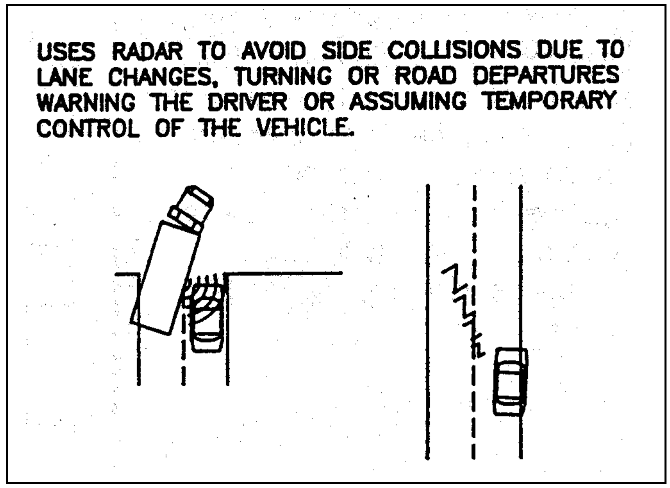
Collision warning/avoidance is divided into two areas, longitudinal and lateral (lateral is discussed under the next heading). The longitudinal aspect of this service refers to impacts from the front or rear (Figure 13). This on-board unit uses radar to locate the edge of the road, other vehicles and surrounding objects. Many times a crash occurs due to human error. If the system senses a possible crash, the driver will be warned by lights and/or buzzers in the vehicle. In more advanced systems, the computer will actually take control of braking and steering temporarily until the vehicle is maneuvered out of danger.



Intelligent Cruise Control is an aspect of this technology. When the cruise control is set, it will adjust the speed to maintain a safe distance from the car in front.

2.7.2 Lateral Collision Warning/Avoidance

This system is the same as Longitudinal Collision Avoidance, except that it deals with collisions due to side impacts. Such accidents could be caused by a motorist falling asleep and drifting off the road or a commercial vehicle changing lanes and sideswiping another vehicle (Figure 14).



2.7.3 Intersection Collision Warning/Avoidance

At some intersections, objects block the view of cross traffic or the right of way is unclear. This system would give warning to drivers of these situations. For example, if two vehicles approach an uncontrolled rural intersection, and neither slows down, a warning message would be sent to the drivers. This warning message could be in the form of in-vehicle signing or a roadside sign with the message "approaching vehicle when flashing". Another example would be an intersection at the bottom of a hill which has a high frequency of runaway trucks. When a truck was approaching a red light at a high speed, the signal controller could change all directions to red, clearing the intersection.

2.7.4 Vision Enhancement for Crash Avoidance

According to “Traffic Safety Facts 1993," published by the USDOT (USDOT, 1993a), 13% of all accidents nationwide occurred during times of poor visibility, arising from conditions such as fog, ground blizzards or dust storms. Vehicles caught in areas of poor visibility face the risk of driving off the road if continuing to travel, or being hit from behind if slowing or stopping. Systems used to enhance vision of drivers may be used either in the vehicle, in the roadway, or both. Vision enhancement includes infrared or radar scopes which allow the driver to see other vehicles. Systems in the roadway could include lighted delineators along the edge of the road. A system that is both in the roadway and in the vehicle could be composed of a magnetic strip on the edge of the roadway and an in-vehicle sensor.

2.7.5 Safety Readiness

Safety readiness is much like On-Board Safety Monitoring, but for noncommercial vehicles. In-vehicle equipment will monitor the driver and critical vehicle components to warn the driver of potential problems.

2.7.6 Pre-Crash Restraint Deployment

This service will use in-vehicle equipment to anticipate imminent collisions. For example, radar would be used to detect objects before they collide instead of the existing deceleration sensors, used for airbags, which detect the collision after it occurs. If a collision occurs, the system will activate passenger safety systems, such as air bags, before the crash occurs, or at the optimal time during the collision, improving their effectiveness.

2.7.7 Automated Highway System

Deploying an Automated Highway System is a long term goal of ITS. It would provide vast improvements in safety by creating a nearly accident free driving environment. Drivers could buy vehicles with the necessary equipment or retrofit their current vehicle. Equipped vehicles would be allowed to enter designated roadways which would communicate with each vehicle's computer to automate the driving task.

2.8 Other ITS Technologies

Many technologies that could be considered ITS related do not fit neatly into a user service area and are not considered in the 29 user services designated by USDOT and ITS America.

2.8.1 Robotics in Road Maintenance

Many accidents occur in construction zones. Robotics can be used in roadway maintenance or construction to remove the worker from the roadway. For example, a worker could control a remote controlled crack sealing machine from a safe distance.

2.8.2 Maintenance Planning

This system may fit under the incident management user service; however, it is unique enough to warrant mentioning separately. This system consists of weather monitors and road sensors used to locate areas in need of snow removal. From this information, snow plow fleets can be deployed in a more efficient manner. The MDT currently uses this system to manage their fleets.

2.8.3 Data Collection

The backbone of many ITS technologies depends on the collection and distribution of information. In addition to data collected to support ITS services (traffic conditions, weather conditions, etc.), MDT collects information for planning, design and management systems. Advanced technologies could be used to improve the data collection process and to enhance the safety of data collectors. In addition, an effort should be made to coordinate efforts to eliminate areas of overlap in data collection. Examples of data collection technologies include:

- Radar vehicle detectors;
- Video detectors;
- Acoustical vehicle detectors; and
- Automated data collection vans.

3 Do Montanans Want ITS?

A major component of this study was the outreach effort with stakeholders. This outreach effort contributed two elements to the ITS program: it educated stakeholders about ITS and current activities and it generated feedback from stakeholders concerning the applicability of ITS. Communication with stakeholders was achieved either by meetings or mail and phone interviews during an eleven-month period. Groups contacted included public agencies (cities, counties, the state, tribes), private companies (commercial vehicle operators), and various motor vehicle related associations. Additional information on stakeholder comments on ITS is available in a supplement to this report (Kwapy, 1996).

Summary of Stakeholder Comments

Of the 35 groups contacted through meetings, and mail and phone, almost everyone wanted to see ITS technologies deployed to improve safety. The following ITS services were most liked by the various groups:

- Construction zone safety systems;
- Collision warning (especially animal collisions);
- Commercial Vehicle Operations (especially electronic clearance);
- Traveler information services; and
- Public transit operations (mainly fleet management).

In addition, these services were also liked by at least one group:

- Safe speed warning system;
- Vision enhancement;
- Slow-moving vehicle warning;
- Drowsy driver alert;
- Incident management;
- In-Vehicle signing;
- Mayday;
- Robotics in road construction;
- Pollution monitoring;
- Sensors to detect ice on bridges or other common hazardous spots;
- Advanced data collection; and
- Advanced signal coordination.

Most groups were in favor of a state plan for ITS deployment. However, there were concerns about:

- Costs and funding (by far the largest concern);
- Driver acceptance;

- Information overload on the traveler;
- Lack of standards;
- Ensure the adoption of quality ITS;
- Retrofitting older vehicles with new technology;
- Liability to the state and private ITS providers;
- Drivers “pushing the envelope” with a safer system;
- Privacy, and misuse of information;
- Compatibility issues;
- Fast obsolescence of expensive systems;
- Maintenance and operation of ITS; and
- Jurisdictional coordination.

4 Existing Systems in Montana

4.1 SCAN Integrated Weather Monitoring System

Beginning in 1986, MDT began to install automated weather reporting stations at strategic locations around the state where weather traditionally impacted the safety of the traveling public. Today, these stations monitor temperature, surface road condition and humidity. The resulting data is transmitted to the MDT. The MDT then provides the public with constantly updated road conditions via a toll-free phone number, highway advisory radio, and the Internet. MDT Highway Maintenance Managers also use the weather station data to more efficiently dispatch snow removal equipment and to monitor highway conditions in general. The approximate locations of the stations are shown in Figure 15.

4.2 Traffic Control

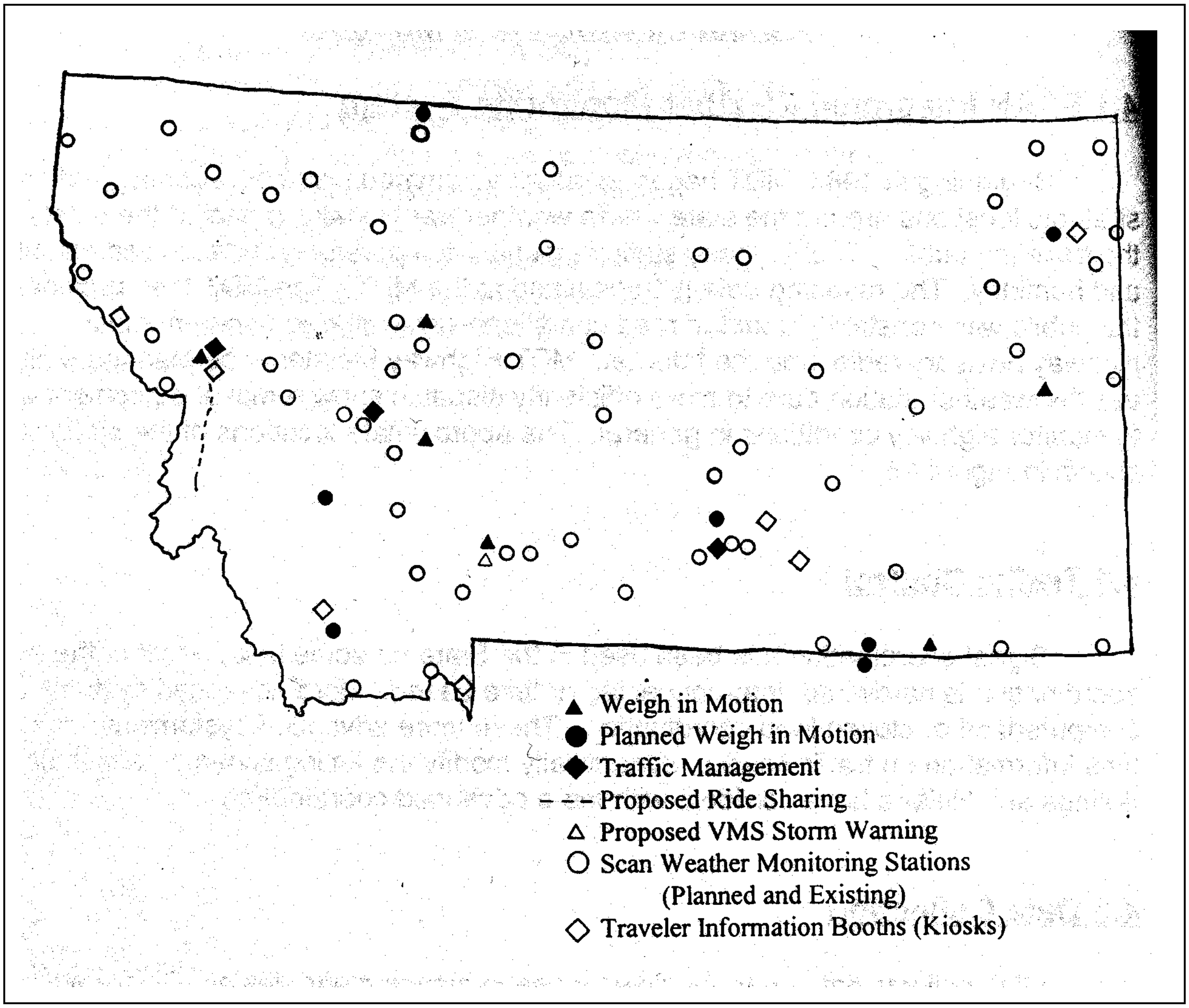
Signal coordination has been used in the State for some time. Most of the signal coordination is hardwired, interconnected or time-based. More advanced systems use computerized or closed loop coordination. These more advanced systems use real-time information on traffic flows to dynamically modify the timing scheme. Missoula, Billings and Helena have corridors with more advanced coordination.

4.3 Data Collection

MDT collects data on traffic flow for use in planning and design. There are currently 65 permanent automatic traffic data collection sites in Montana which measure traffic volume, axle configurations and speed. MDT also owns approximately 85 portable automatic traffic data collection systems. This data is used by MDT for planning and engineering purposes.

4.4 Weigh-in-Motion

In 1993, MDT installed the first of seven remote (WIM) systems. The last six of these seven sites will be operational during the summer of 1997. Six additional WIM sites are proposed. The locations of these sites are shown on Figure 15. Each WIM provides commercial vehicle counts, gross vehicle and axle weight, axle spacing and other vehicle category data. This information can be collected 24 hours per day, 365 days a year, if necessary, as the vehicle being monitored travels at highway speeds over the WIM sensor imbedded in the surface of the highway. The data is utilized by the MDT Planning Division, Engineering Division and Motor Carrier Services Division to make strategic traffic, highway design and commercial vehicle enforcement decisions.


▲ Weigh in Motion
● Planned Weigh in Motion
◆ Traffic Management
- - - Proposed Ride Sharing
△ Proposed VMS Storm Warning
○ Scan Weather Monitoring Stations (Planned and Existing)
◇ Traveler Information Booths (Kiosks)

4.5 Heavy Vehicle Electronic License Plate , Inc.

West of the Mississippi, Heavy Vehicle Electronic License Plate Incorporated (H.E.L.P. Inc.) is the industry leader in the deployment of technology related to commercial vehicle operations (CVO). H.E.L.P. Inc., in partnership with Lockheed-Martin and the state of California, currently operates seven automated weigh station facilities between San Francisco and the California/Mexican border. Any commercial carrier electing to join H.E.L.P. Inc. is thereby allowed to bypass these automated weigh stations providing each individual truck is weight, safety and credential compliant.

The ITS technology involved in the bypass process includes weigh-in-motion (WIM); automated vehicle identification (AVI); electronic license plate reading (LPR); and vehicle-to-roadside communication (VRC).

Currently, California, Montana and nine other western states are H.E.L.P. members. Montana has been an associated member of the H.E.L.P. Board of Directors since 1993. In return for the cost of membership, MDT has received extensive ITS design and engineering support, and training from both H.E.L.P. staff and from Lockheed-Martin. Because this support and training was unavailable inside MDT, the H.E.L.P. Inc. membership connection has proven very valuable as MDT works toward a final design for Montana's first automated weigh stations located on Interstate 90 East/West between Billings and Laurel.

5 Systems Being Developed by Montana

5.1 Traveler Information

The Montana Tourism and Recreation Initiative (MTRI), a group composed of Travel Montana, MDT and many others, is currently developing 10 traveler information booths (kiosks) which will be placed around the state in strategic locations (Blackwood, 1995). The kiosks will have touch screens to enable the traveler to access information on recreation facilities, hotels, trails, rivers, lakes, construction zones, weather and transit. Each kiosk will have its own database of information updated when needed and feasible. MTRI will sell the kiosks, as well as the software for use on personal computers, at cost. Some of the potential kiosk sites are shown in Figure 15.

5.2 Traffic Control

Missoula is in the process of designing a traffic management system. A camera pointing at downtown and several loop detectors will collect information and send it to a traffic control center where signals will be synchronized to maximize traffic flow. This system will manage traffic and detect incidents.

5.3 Ride Matching

Local officials in the Bitterroot Valley are currently looking into developing ride matching. Currently, they are in the idea phase. It is unclear what specific type of system will be implemented and what funding will be required. They should be given assistance in developing their system. The Bitterroot system could be used to test different software and could serve as an example for other areas in the State.

5.4 On-Board Computers for Law Enforcement Vehicles

The Department of Justice is consolidating the State's emergency mobile communication system. Currently, every county has their own separate mobile communication system which is not inter-operable with surrounding counties. As part of the consolidation process, the Department of Justice is testing five mobile on-board computers in enforcement vehicles to determine data requirements and any possible problems which might be encountered. The on-board computers will allow law enforcement personnel to quickly access databases with information on wanted felons, stolen cars, etc.

6 Potential Systems for Montana

There are many Intelligent Transportation System technologies which are applicable to Montana. This section identifies those systems which could be deployed in Montana. There may be other systems which have not been included that, as new information becomes available, may be feasible. These applications are not prioritized, so both necessary and simply desirable technologies are included. A more detailed benefit/cost analysis of these potential systems needs to be completed.

6.1 Data Collection

Techniques such as overhead radar may be used to track multiple lanes without costly construction needed for loop installation. Data collection devices which can be remotely accessed to download information can save time and money. New data collection technologies should be tested as they become available to continue with efforts to consolidate data collection.

6.2 Electronic Clearance

Currently, Heavy Vehicle Electronic Licence Plate Incorporated (H.E.L.P. Inc.), a non-profit organization, is deploying electronic clearance in the western states, including Montana. Montana could continue their involvement in H.E.L.P. Inc. and target problem areas such as the Coutts, Canada/Sweetgrass, Montana border crossing. The Coutts/Sweetgrass crossing is currently the focus of MDT/Alberta Transport and private partnerships to expedite the installation of pre-clearance ITS technologies.

6.3 Automated Safety Inspection

There are existing systems which automate safety inspections, making them faster and more accurate. Montana could test some of these systems to determine their effectiveness and acceptance by the motor carriers.

6.4 In-Vehicle Safety Devices

There are many devices being developed for vehicles by private industry to improve safety. These include the Mayday system, collision warning, vision enhancement and in-vehicle signing. As these systems are developed by private industry, Montana should keep abreast with developments. When necessary, Montana could push for legislation to ensure reliable systems are produced and to encourage their use. Also, systems which may improve safety, but are not being deployed by private industry, could be tested on MDT vehicles.

6.4.1 Mayday

There are two problems with the Mayday system. First, cellular phones are often used for the communication medium; cellular coverage apparently is limited on many low volume roads where Mayday is most useful. Second, many 911 centers have refused to take automated emergency calls because of the large number of false alarms they receive from home security systems.

6.4.2 Collision Warning/Avoidance

This service will reduce the number of accidents, resulting in a huge savings to society. Intersection collision avoidance will most likely have infrastructure components and could be tested at intersections with frequent accidents. Stand alone, in-vehicle collision warning/avoidance is currently being developed by private industry.

6.4.3 Vision Enhancement

Most Montanans know the feeling of being stuck in a ground blizzard where they could not see ten feet in front of the car, but are afraid to stop for fear of being rear-ended. Vision enhancement could be a stand alone, in-vehicle system using radar to track objects. In this case, the State should keep abreast and encourage legislation as mentioned above. Other possibilities require infrastructure in the roadway consisting of lighted delineators or buried cable in the roadway which could be tracked by an in-vehicle device.

6.4.4 In-vehicle Signing

In-vehicle signing also requires infrastructure and in-vehicle coordination and is still in its infancy. As systems develop, MDT should consider the costs and benefits of such systems.

6.5 Robotics in Road Construction and Maintenance

In 1993, 830 people were killed in construction zones in the United States (USDOT, 1993a). By using robotics, MDT can remove workers from the roadway and possibly reduce the amount of time the road is under construction. Examples of systems currently available or being developed are:

- Remote control dump truck, developed by Minnesota DOT;
- Crack sealing machine, developed by University of California, Davis; and
- Remote bridge inspection, developed by University of California, Davis. (University of California, Davis,1995)

6.6 Work Zone Traffic Control

Again, work zones can be a very hazardous place. A work zone warning system, for example, would trigger a warning message for in-vehicle signing or a variable message sign, warning vehicles as they are detected in the work zone.

6.7 Animal Collisions

Table 1 shows the number of animal collisions in Montana. Animal Collisions are costly to motorists and MDT. MDT should look at possible solutions to this problem. An example of a potential system would initiate active signs (e.g., VMS or static sign with a flasher) when infrared sensors detect animals in the vicinity.

Table 1. ANIMAL-VEHICLE ACCIDENTS IN MONTANA

YEAR	TOTAL	FATAL	INJURY	PROPERTY DAMAGE ONLY
1989	587	0	90	497
1990	658	2	83	573
1991	720	3	96	621
1992	810	3	118	689
1993	807	3	103	701

Source: Reference (Jomini, 1995)

6.8 Emissions Testing and Mitigation

Emissions testing and mitigation may not appear to be a need in a rural state such as Montana; however, it is a concern in some urban areas such as Missoula. These areas could look at some of the work done by Idaho in the area of remote emissions testing.

6.9 Slow-moving Vehicle Warning

There are a number of accidents involving blinded motorists rear-ending slow-moving snow plows. An electronic vehicle flare could be tested on MDT vehicles. With this system, a signal would be emitted by the slow-moving vehicle. The trailing vehicle would pick up this signal, via in-vehicle signing, and be warned. Another type of system is the extended tail light. With this system, delineators would be equipped with visibility sensors, motion detectors and lights. When there is low visibility and a vehicle passes the delineator, it will light up for a few seconds, creating a trail of lights following the vehicle.

6.10 Incident Management

When a bad storm hits Montana, roads are closed, vehicles slide into the ditch and the public is looking for information to decide whether or not to travel. These activities could be better coordinated. Road closure signs could be remotely controlled from a central office. This same central office could coordinate efforts from MDT, Montana Highway Patrol, radio stations and tow trucks.

6.11 Slippery Conditions Warning

Sensors could be placed at locations where ice or water can cause dangerous situations such as bridges or curves. This information could be displayed to the driver through a variable message sign or in-vehicle signing. This information could also be used by MDT Maintenance for deicing.

6.12 Safe Speed System

Information on curve alignment, grades, vehicle weight and slippery conditions could be used to calculate a safe speed for the vehicle. This speed could be displayed to the driver via a variable message sign or in-vehicle signing.

6.13 Intersection Collision Warning

Many uncontrolled intersections in Montana have poor sight distance. Intersection collision warning technologies could reduce the number of accidents in this area.

6.14 Advanced Tourist Information

The existing kiosk program could be expanded to maintain a central database which is updated often enough to maintain real-time information. This database could be accessed by personal computers, portable hand held devices and in-vehicle components. This database could also be tied into MDT weather incident response efforts.

6.15 Active Logo Signing System

This is a very simple system that consists of a road sign with services information such as gas and lodging. There is a light next to each service which would be on when the service was open and off when the service was closed.

6.16 In-vehicle Navigation

There are already navigation systems available to some areas of the country. With a system in the vehicle, the driver would enter the destination and the system would give the driver step by step directions. For systems to be available nationwide, there needs to be a standardized map data format and map databases for all areas of the country. FHWA is currently contracting with Oak Ridge National Laboratories to develop a standard format for map databases. Montana should keep abreast with the development of map standards and potentially aid in the development of a Montana map.

6.17 Advanced Public Transit Systems

Software and communication could be used by some transit agencies to better manage their fleets. Also, transit schedules could be included in information kiosks.

6.18 Overlapping Areas

Potentially, all areas within MDT will be involved in the ITS program. There are several areas of ITS which could overlap within MDT in the future implementation of ITS. An overlap will exist between planning and engineering. There are several applications of ITS in the more urbanized areas which serve as both traffic monitoring and data collection. This overlap is currently occurring in metropolitan areas with closed loop signal systems. These systems are designed to have computers control signalized intersections to optimize traffic flow. At the same time, the systems can serve as fact gathering resources, supplying a large amount of data for planning.

Interagency overlap also exists with the implementation of weigh-in-motion planning.

Planning can use axle counts, weights and total vehicle counts to plan for future infrastructure. The Motor Carrier Services Division will use the information to assist in projects such as H.E.L.P. Inc. The Motor Carrier Services Division also can project staffing requirements for future use. Interlap occurs here with bordering states and provinces, as well.

Maintenance and engineering will see an overlap in robotics. Equipment used to check the condition of bridges may benefit from particular bridge designs. Machines designed to survey roadway surface conditions (i.e. smart vans) can also gather data valuable to future engineering of roadways.

Road construction and survey crews will benefit from warnings provided by work zone advisory systems. These systems can also provide traffic count and delay information which will be useful in future projects. This delay information may be beneficial to those agencies involved in promoting the touch screen traveler information kiosks throughout the State, as tourists could be warned of construction delays prior to departure and make appropriate plans.

Maintenance and planning could also overlap in the applications of remote weather stations and automatic dispatching. The same sensor arrays that provide information about surface and atmospheric conditions can also be equipped with sensors to count axles and vehicles. Engineering could benefit from these data as well, in that alignments and safe speeds will be tested (a system to count vehicles, determine speed and sense axles can be configured).

There are several other possible scenarios for overlap in the system. In order to assure that overlap is anticipated and dealt with, a strategic plan and a specific office or point of contact should be developed to direct ITS applications and to assure that all data reaches the appropriate personnel.

7 RECOMMENDATIONS FOR SUCCESS OF PROGRAM

7.1 ITS Strategic Plan for Montana

In order to continue with the deployment of ITS in Montana, a strategic State plan is needed. Many systems require the same communication infrastructure, information and/or in-vehicle equipment. This situation allows for a building block deployment in which future systems could piggyback on earlier systems. To do this efficiently, a plan is needed that looks well into the future and is updated regularly.

One of the objectives of this study was to determine if Phase II, the development of a Montana ITS plan, was needed. Not all stakeholders were in favor of full scale ITS deployment. However, most stakeholders felt the technology was upon us and wanted to see some sort of state ITS plan. Also, TranPlan 21 suggests that MDT develop an ITS strategic plan. For these reasons, it is recommended that the Montana Department of Transportation develop a Long-Term Statewide ITS Deployment Plan.

7.2 Organization and Staffing

A program coordinator is important to the establishment and initial success of an ITS program in Montana (an ITS plan should help to establish long-term ITS unit staffing levels). The program coordinator would keep abreast of all ITS activities, allowing for better coordination of efforts and to facilitate the development and implementation of the plan. The program coordinator would monitor the progress of the program to foresee any potential difficulties. The coordinator could also be the liaison to other agencies involved in the development of ITS. The Department of Justice, for example is currently working on combining the State's emergency mobile communication infrastructure and testing onboard computers in police vehicles. These activities need to be coordinated with the program.

All interested parties must be involved from the beginning. There has been a good start with the composition of the technical panel overseeing this study, with representation from AAA, Montana Motor Carrier Association and Montana counties. This needs to continue throughout the development of the program. Some states have included non-department members in their program advisory committee, such as representatives of private industry, and the public. The most successful programs have included nondepartmental members in some way from the beginning. This practice is strongly recommended for Montana.

7.3 Education and Outreach

During the outreach portion of this study, it was discovered that many transportation planners are unaware of ITS and similar developments. A continued effort is necessary to inform planners and the general traveling public on ITS. Without buy-in from these two groups, transportation planners and the public, the ITS program will not succeed

7.4 Privacy, Liability, Reliability and Other Institutional Problems

There are many problems that have been foreseen for some time by ITS America. Such issues include privacy, liability, and standardization. Groups within ITS America are working on resolving such issues. As they develop solutions, Montana needs to keep informed and adopt these solutions. An example is the ITS America development of the privacy guidelines (ITS America, 1995).

7.5 Ensure Reliability and Quality of Investment

Investing in a system that works poorly because of system/component failure, poor interface with the user, and/or costly maintenance and operating expenses, is not cost effective and provides a poor image to the public and transportation planners. If a system is to be invested in, it needs to be reliable and durable, and to provide adequate quality to the user. To ensure these qualities, MDT should:

- Have an ITS coordinator knowledgeable of ITS products;
- Provide for user feedback on technology performance;
- Ensure products conform to national standards; and
- Develop specification and standards where they do not exist nationally.

8 STATUS OF OTHER STATES' AND COUNTRIES' ITS PROGRAMS

This section contains a brief overview of the ITS programs of several states around the U.S. Programs in Europe and Japan are also discussed.

8.1 United States

Discussion of the programs in some of the states leading the deployment of ITS, as well as some rural western states, are included in this section. During the deployment of their ITS programs, states have encountered these four problems most often:

- Funding (or lack thereof);
- Institutional issues, including difficulty with current contracting mechanisms;
- Lack of consensus within and outside of the DOT (i.e., selling the benefits to top level administrators); and
- Jurisdictional barriers.

A comparison of some states' progress with planning elements of their ITS programs can be found on Table 2. A brief discussion of specific activities in each state follows.

8.1.1 California (California DOT, 1995)

California labels their program Advanced Transportation Systems (ATS), instead of ITS, to include areas which are not generally considered ITS, such as maintenance aids (i.e., robotics) and low emission vehicles. The ATS program is under the New Technology and Research Program. In addition, there are management teams in each district which are composed of State and local officials and private industry. California is involved in almost every area of ITS including rural applications. A few of their main involvements are listed below.

- Partnership of Advanced Rural Transportation Systems (PART)
- TravInfo operational test
- Automated Highway System
- Alternative fuels
- H.E.L.P. Crescent operational test
- Automated maintenance
- SCOOT traffic signal coordination system

Table 2

STATES	ITS AMERICA STATE CHAPTER CHARTER	STATE ITS STRATEGIC PLAN ADOPTED	ITS PROGRAM COORDINATOR	OPERATING LARGE SCALE TRAFFIC MANAGEMENT CENTERS
CALIFORNIA	Y	Y	Y	Y
COLORADO	R	Y	Y	Y
GEORGIA	N	Y	Y	Y
IDAHO	R	N	Y	N
ILLINOIS	M	N	Y	Y
MINNESOTA	Y	Y	Y	Y
MONTANA	**R**	**N**	**Y**	**N**
NORTH DAKOTA	N	N	N	N
NORTH CAROLINA	N	Y	Y	Y
OHIO	Y	N	Y	Y
OREGON	N	N	Y	Y
SOUTH DAKOTA	N	N	Y	N
WASHINGTON	Y	Y	Y	Y
WYOMING	R	N	N	N

Y = YES
N = NO
R = MEMBER OF ROCKY MOUNTAIN CHAPTER
M = MEMBER OF MIDWEST CHAPTER

8.1.2 Colorado (Castle Rock, 1993; Castle Rock, 1994a)

The ITS program is housed in the Research and Development (R&D) section, which is under the Division of Transportation Development (TDT). Approximately one third of the R&D budget is used for ITS. R&D will coordinate newer technologies and roll them over into the appropriate department.

Colorado is currently involved in the following areas:

- Traffic management centers;
- Alternate route information;
- Information available from State Patrol and a 1-800 number for State employees to report problems; and
- Weather incident information sent out through an automated fax to 165 people (radio, trucking, etc.).

The major problems that Colorado has run into are:

- Institutional Barriers;
- Allocation of resources;
- Funding;
- Turf issues; and
- Lack of public consensus.

8.1.3 Georgia (Stapleton, 1995)

They are currently understaffed, with only three people in the traffic operations office coordinating all the ITS activities in the State. These three people also have other duties outside of ITS. Georgia is working on the following areas:

- Computer coordinated traffic signals;
- Traffic management centers;
- Fiber optics;
- Closed circuit TV cameras;
- Detection loops;
- Scope detection;
- Variable message signs;
- Highway advisory radio;
- Ramp metering; and
- Kiosks at 150 locations - traffic management centers supplement traffic info to kiosks and Internet.

Their biggest problem is coordinating the timing between projects and funding.

8.1.4 Idaho (Laragan, 1995)

Idaho has one ITS staff member who also performs other duties. This staff member coordinates projects from the front end and then hands duties over to project managers and other departments. Idaho is currently working on:

- Storm warning and poor visibility detection operational test;
- Emissions testing;
- I-84 corridor study; and
- Out of service verification of commercial vehicles.

8.1.5 Illinois (Ligas, 1995)

The ITS program is housed under the Programming and Planning office. There are four full-time positions to support ITS coordination. Illinois is currently involved in:

- Traffic management;
- Highway advisory radio;
- Incident management; and
- Multi-state Midwest corridor.

They have run into some problems with contracting procedures. For traditional transportation systems, the existing contract mechanism is satisfactory. However, for non-traditional systems, there have been problems. Illinois has found that a good way to alleviate contract problems and save money is the development of Public/Private partnerships.

8.1.6 Minnesota (BRW, 1993; University of Minnesota, 1994; Castle Rock, 1994b; Castle Rock, 1994c)

Minnesota is one of the leading states in terms of rural ITS applications. They are involved in some way in every area of ITS. The program is organized through Minnesota DOT's Office of Special Projects/Minnesota Guidestar into committees composed of individuals working in public and private industry and academia. Each district within Minnesota DOT has a dedicated ITS champion. Their annual budget is approximately $40 million, and can be broken down into the following categories:

57% Federal,
21% MnDOT,
22% Private.

8.1.7 North Dakota

There is no staff dedicated specifically to ITS projects. North Dakota has received some congressional funding earmarked for the University of North Dakota, although most of their ITS program consists of work done in conjunction with South Dakota.

8.1.8 North Carolina (Fuller, 1995)

The North Carolina ITS program is split between two departments, with four ITS staff in Traffic Management Systems and 10 - 12 individuals in Congestion Management. They have determined and convinced legislators that machine vision is more economical than a system of inductive loops. North Carolina is currently working on the KARROT project, which includes:

- Transportation management centers;
- Closed circuit television cameras;
- Machine detection (testing four different systems);
- Fiber optics;
- Variable message signs;
- Reversible lanes; and
- WIM used for enforcement (license plate readers).

8.1.9 Ohio (Salor, 1995)

Currently Ohio DOT is undergoing restructuring and waiting to hear how ITS will be structured in the future. In the past, there was an executive level committee and an ITS subcommittee. The executive level committee made all the decisions and the subcommittee, composed of nine bureau chiefs, deployed and operated the systems. Their biggest problem was bridging the gap between the two committees. The executive level committee knew little about the specific problems and benefits of ITS. Whereas the subcommittee was very knowledgeable, but had no administrative authority.

Ohio DOT recently received four federal early deployment grants. There is a lot of money for research and testing (operational tests); however, there is little money for deployment due to the competition between construction and ITS for funds. Ohio has the following ITS projects currently in operation:

- ITS Ohio State Chapter;
- Rural corridor I-71; and
- Transportation management.

8.1.10 Oregon (Oregon DOT, 1993; Oregon DOT, 1994)

Green Light is Oregon's premier ITS program. The focus of the Green Light program is the development of CVO/ITS applications; the plan is ambitious and progressive. The total cost for deploying the CVO projects, including 15 electronic clearance sites and 4 safety enhancements, is expected to be $23.5 million. Also, an early deployment plan was completed for Portland in 1995 which details the deployment of ITS services in that area, mostly advanced traffic management. Oregon is still in the process of developing a statewide strategic ITS plan.

8.1.11 South Dakota

South Dakota's ITS staff currently consists of one position, the Director of Research/ITS Coordination, with no dedicated staff. There is an informal group which meets to aid in the direction and planning of ITS. This group includes representatives from the Highway Patrol, Department of Revenue, public utilities and FHWA. South Dakota is in the process of developing a long range plan. They do not have much ITS activity in their state. However, they are working on several projects with other states, including:

- Iowa institutional issues study;
- North Dakota's institutional issues study;
- North Dakota time and place specific weather detection providing information to maintenance, CVO and public; and
- Midwest states one stop credentials for CVO (Minnesota, Missouri, Illinois, Indiana).

8.1.12 Washington (JHK, 1995b)

Washington has a state strategic plan for ITS entitled Venture. The Venture program focuses on traffic management, public transit, traveler information and commercial vehicle operations.

8.1.13 Wyoming (Vandel, 1995)

Wyoming has a steering committee for ITS projects, but does not have a defined ITS program. They are participating in a few operation tests with other states, mostly in the area of commercial vehicle operations.

8.2 Europe

In the mid 1980's, Europe began DRIVE, an ITS planning program coordinated through the European Community (EC). The focus of DRIVE has been pilot projects, demonstrations, and standards. The program receives about half of their funding from private industry. DRIVE III (1994-1998), the current funding stage, is expected to spend approximately $180 million.

PROMETHEUS (PROgraMme for a European Traffic system with Highest Efficiency and Unprecedented Safety) is the largest and most widely known ITS program in Europe. This program is developing and testing multinational vehicle-oriented ITS projects. PROMETHEUS is largely funded by industry, but receives some government contributions. The original planning called for $770 million in funding during the 1986-1993 period. Many countries in Europe have also made great progress in ITS projects relating to mass transit.

The largest constraint to Europe's ITS project stems from each country having their own priorities and implementation approach. This situation creates a difficult environment in which to create systems that are seamless across national boundaries.

8.3 Japan

Japan has a strong ITS program because of consistent government funding and their large need for ITS due to congestion and insufficient room to expand roads. Their largest focus has been traffic management and navigation systems. It is estimated that the government has spent $1.9 billion on traffic management centers and information collection technologies in the 1985-1992 period.

The Japanese industry has sold approximately 500,000 autonomous navigation systems from 1987 to 1993, ranging in cost from $2000 to $6000. At the end of 1993, approximately 20,000 systems were sold per month, driving prices down below $2000.

The biggest obstacles come from turf struggles between government agencies. Japan is attempting to remedy this by forming VERTIS/IMC (Vehicle, Road and Traffic Intelligence Society/Inter-Ministry Committee) in January 1994. This organization, much like ITS America, is a coalition of five government agencies, private industry and academia.

9 Cost per Stop of Commercial Truck

9.1 General

This section is dedicated to determining a cost per stop of commercial vehicles at weigh stations to aid in determining the benefits of electronic clearance in Montana. Commercial vehicles are required to stop at each weigh station as they travel Montana's highways and interstates. The weigh stations check the truck's weight, safety and credentials to ensure that commercial vehicles are operating legally and safely. An electronic clearance system would allow commercial vehicles to bypass weigh scales maintaining mainline speeds, while the weigh scales would check their weight and credentials. It is anticipated that the savings realized by motor carriers will be passed on to the public through reduced freight transport charges.

The cost per stop is determined by calculating the additional costs to the motor carrier resulting from stopping at a weigh station, instead of bypassing at mainline speed. The factors involved in the calculation are:

- Time (operating costs);
- Vehicle wear (brakes and tires);
- Fuel consumption (acceleration and idling); and
- Costs related to delays in delivery of goods.

9.1.1 Time

Inherent in the operation of a commercial vehicle are hourly operating costs relating to the driver's wages, general vehicle maintenance and depreciation costs of the vehicle. It should be noted that these hourly costs may vary depending on the driver, vehicle and carrier. The time lost from a stop at a weigh station depends on:

- Weigh station geometry;
- Scale operator;
- Truck size;
- Load size;
- Queue lengths (depending on truck volume); and
- If the truck is stopped.

A truck may be stopped for any of the following reasons:

- Excess weight violations;
- Obvious safety problems;
- Random safety check; or
- Random permits check.

9.1.2 Vehicle Wear

The main vehicle wear from one stop includes brake and tire wear. Brake wear includes the excess wear caused by one stop from 97 km/h to 0 km/h (60 mph to 0 mph). Excess tire wear includes the wear caused by decelerating from 97 km/h (60 mph) to a stop plus accelerating from a stop to 97 km/h (60 mph).

9.1.3 Fuel Consumption

Costs of fuel consumption include fuel consumed while idling in the queue, and fuel used to accelerate from 0 km/h to 97 km/h (0 to 60 mph), less the fuel that would be used to travel the same distance at mainline speeds.

9.1.4 Delay Costs

The cost of delays in delivery of goods is non linear and difficult to quantify. For example, next day delivery of goods is more expensive than next week delivery, even though the same weight was transported over the same miles. A nominal value of $1.00 for these delay costs was assigned by NCHRP Report 303 (Grenzeback, 1988). For this analysis $1.00 will also be used.

9.2 Research Procedure

The largest and most variable cost is the time savings. In order to determine an average time of delay, a traffic study was made at three weigh scales around Montana. The three weigh scales were:

- Billings/Laurel on I-90;
- Butte/Rocker on I-90; and
- Coutts/Sweetgrass Canadian border crossing on Canadian highway 4.

The layout of each scale is shown in Figures 16, 17 and 18, respectively. Times required for a commercial vehicle to decelerate, negotiate the weigh station, and

Figure 16 -- Billings/Laurel Weigh Station on Interstate 90

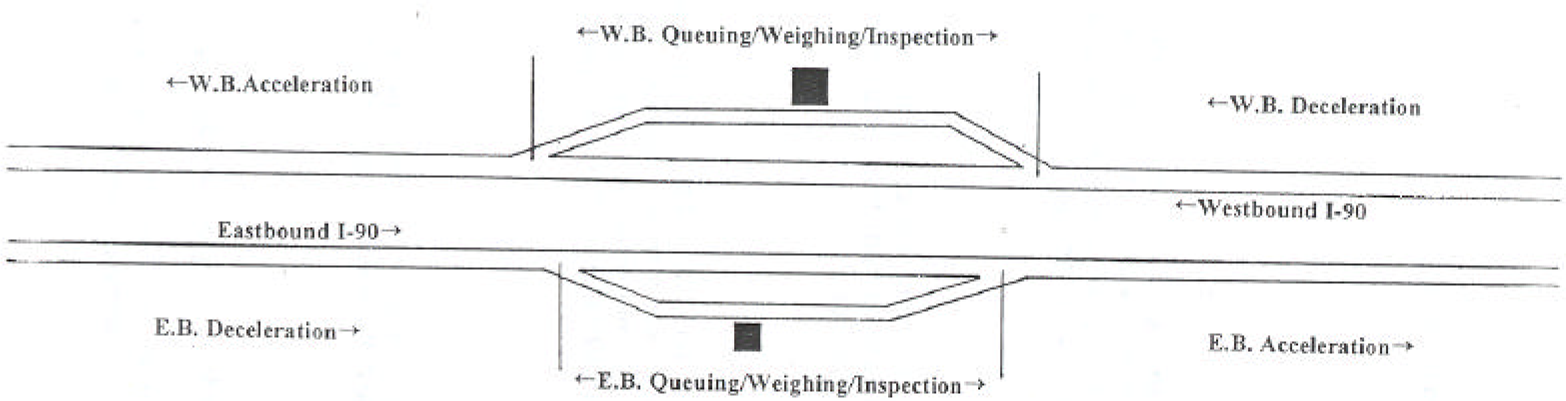


Table 3

Link	Length	Min. Time Lost	Max. Time Lost	Avg. Time Lost
W.B. Deceleration	305 m (1001 ft)	1 s	12 s	5 s
W.B. Q/W/I	582 m (1909 ft)	16 s	287 s	95 s
W.B. Acceleration	693 m (2274 ft)	9 s	36 s	21 s
E.B. Deceleration	271 m (889 ft)	1 s	12 s	5 s
E.B. Q/W/I	573 m (1880 ft)	11 s	224 s	73 s
E.B. Acceleration	631 m (2070 ft)	9 s	21 s	14 s

W.B.: Total Time Lost: 121 s

E.B.: Total Time Lost: 92 s

*See assumptions.
*Grades at the Billings/Laurel weigh stations are negligible.

Figure 17 -- Butte/Rocker Weigh Station on Interstate 90

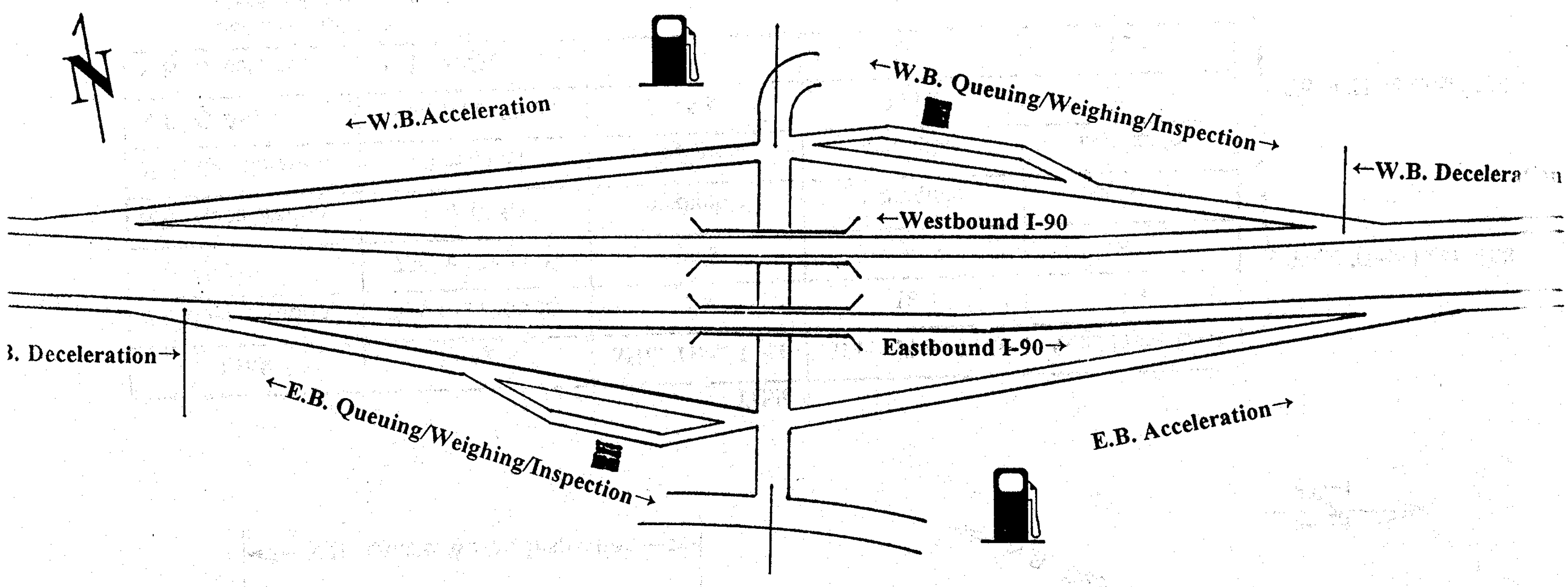


Table 4

Link	Length	Avg. Grade	Min. Time Lost	Max. Time Lost	Avg. Time Lost	
W.B. Deceleration	305 m (1001 ft)	-3.8%	1 s	12 s	4 s	
W.B. Q/W/I	456 m (1496 ft)	-2.5%	52 s	257 s	120 s	Total Time Lost: 155 s
W.B. Acceleration	1046 m (3432 ft)	+0.2%	19 s	42 s	31 s	
E.B. Deceleration	305 m (1001 ft)	-0.1%	1 s	12 s	5 s	
E.B. Q/W/I	540 m (1772 ft)	-1.6%	8 s	257 s	103 s	Total Time Lost: 187 s
E.B. Acceleration	1521 m (4990 ft)'	+2.1%	68 s	106 s	79 s	

*See assumptions.

Figure 18 -- Coutts/Sweetgrass Weigh Station

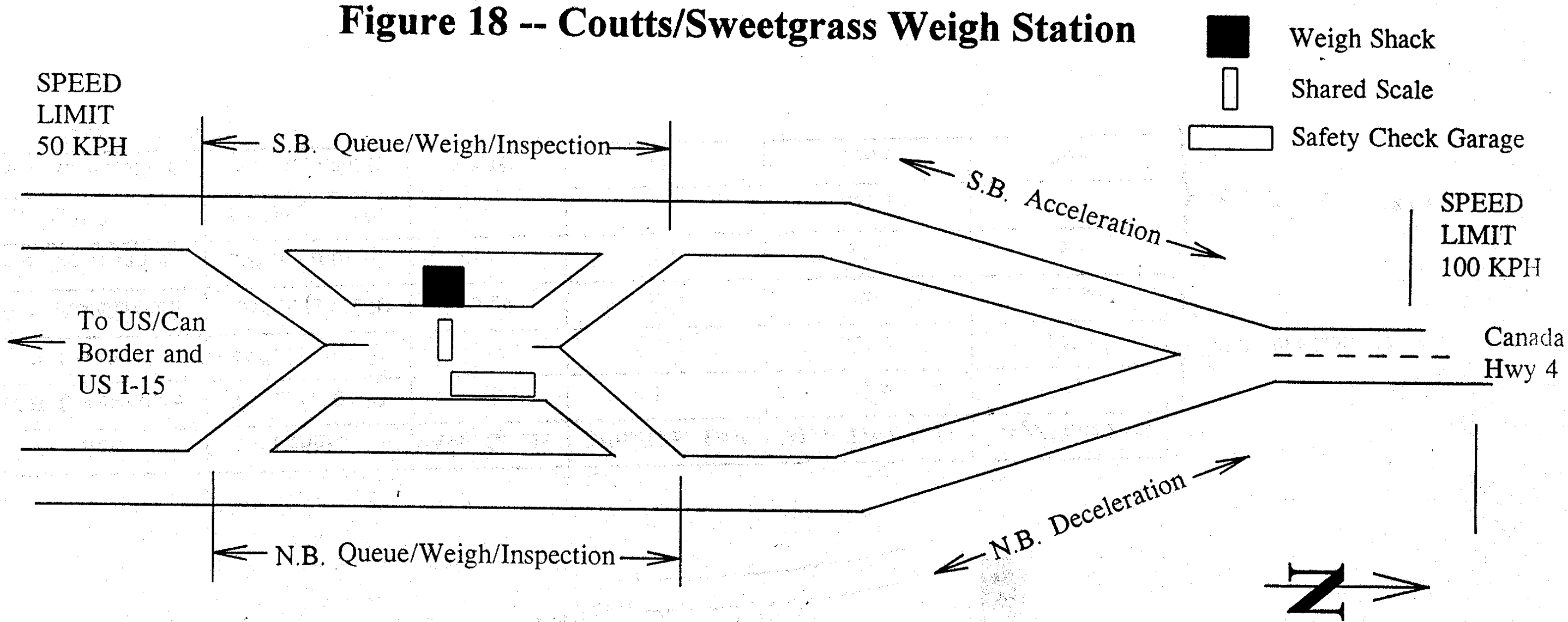


Table 5

Link	Length	Min. Time Lost	Max. Time Lost	Avg. Time Lost	
S.B. Deceleration	539 m (1768 ft)	1 s	18 s	8 s	Total Time Lost: 168 s
S.B. Q/W/I	759 m (2490 ft)	76 s	776 s	160 s	
S.B. Acceleration	0 m (0 ft)	negligible	negligible	negligible	
N.B. Deceleration	0 m (0 ft)	negligible	negligible	negligible	Total Time Lost: 139 s
N.B. Q/W/I	668 m (2192 ft)	15 s	388 s	127 s	
N.B. Acceleration	1113 m (3652 ft)	1 s	52 s	12 s	

*See assumptions

*Grades at the Coutts/Sweetgrass weigh station are negligible reaccelerate were recorded and averaged. The time it would have taken a truck to travel these same lengths at 97 km/h (60 mph) was calculated and subtracted from the averaged time to compute a time lost. These times are summarized in Tables 3, 4 and 5, respectively. Not all trucks were included in the total average. Single unit trucks were not included in the averages because it was assumed that they would not subscribe to the electronic clearance service since they generally run short routes thereby decreasing the cost effectiveness for them. It was also assumed that electronic clearance users would still be stopped for random safety checks and obvious safety problems. Therefore, the trucks that were stopped for safety checks were not included either.

9.3 Findings

9.3.1 Time

The average operating cost for a truck and driver varies greatly. The Western Highway Institute uses $1/minute as a general rule of thumb (Heald, 1995). This estimate is considered to be conservative (high). NCHRP Report 303 uses $0.58/minute (Grenzeback, 1988). This estimate represents the mid-range of hourly operation cost based on the literature and interviews. Oregon, in the cost benefit analysis of their Greenlight CVO Project, estimates operating cost at $0.73/minute (Oregon DOT, 1994). From interviews with several Montana motor carriers and the information mentioned above, a best estimate including driver wages, depreciation and general maintenance was determined to be $0.73/minute.

9.3.2 Tire wear

Limited information is available on tire wear due to stopping and starting, therefore the cost due to tire wear is difficult to estimate. Tire manufacturers feel that it is negligible (Orlando, 1995). NCHRP Report 111 (Claffey, 1971) estimates $0.012 for passenger cars for one stop and start at 97 km/h (60 mph). Commercial Vehicles, however, have more tires, more expensive tires, and greater weights than passenger cars. Given tire costs and expected tire wear of commercial vehicles, a value of $0.35 was assigned for tire wear.

9.3.3 Brake wear

The most detailed data on brake wear is found in the report entitled "An In-service Evaluation of the Reliability, Maintainability and Durability of Antilock Braking Systems (ABS) for Heavy Truck Tractors" (USDOT, 1992). In this report, 200 commercial vehicles with ABS brakes were monitored for two years. The purpose of the study was to determine the extra cost for the ABS components of the braking system. However, from the data in the report, a high estimate of wear on the entire braking system is calculated by making two assumptions. First, one stop 97 km/h to 0 km/h (60 mph to 0 mph) is equivalent to one heavy braking application, as classified by the report. Second, the light braking applications cause insignificant damage to the brake system. From the data in the report, given the assumptions above, the cost associated with the wear on the brakes for one stop is $0.12.

9.3.4 Fuel costs

As mentioned previously, excess fuel consumption results from idling in the queue and one reacceleration. From NCHRP 111 (Claffey, 1971), excess fuel consumption for commercial vehicles is found to be 0.0265 L/s (0.007 gal/s) while idling and 0.76 L (0.2 gallons) for one acceleration from 0 km/h to 97 km/h (0 mph to 60 mph). In addition, Cummins Engine Company calculated the fuel consumption due to one acceleration at two weigh stations. The first weigh station was Butte eastbound, with a steep incline on the acceleration. The second weigh station had flat slopes on the acceleration, typical of the other two weigh stations studied. Results were calculated for various engine types, accessory power, and gross weight. Depending on these variables, excess fuel burned for the acceleration on the Butte eastbound ranged from 0.3293-1.0751 L (0.087-0.284 gallons). The weigh station with the flat grades ranged from 0.2650-0.6057 L (0.070-0.160 gallons). For this analysis, the mid-range of these values will be used for the acceleration fuel cost. For idling, fuel costs 0.0265 L/s (0.007 gal/sec) will be used. The cost of diesel fuel in Montana is approximately $0.35/L ($1.31/gal). Therefore the following fuel costs will be used:

- Cost for idling in queue **$0.00917/sec**
- Cost for acceleration (Butte eastbound) **$0.24**
- Cost for acceleration (other scales) **$0.15**

9.4 Summary of costs

The average cost for a commercial vehicle to stop at a weigh station was found to be approximately $4.40. The results of the total cost analyses are included in Table 7. These costs include brake and tire wear, fuel consumption, and delay and operational costs. There are many variables involved which are difficult to pinpoint (i.e. scale operator technique, driver technique, truck type and load). These variables are evident in the differences between times lost at the different scales in Table 7.

Table 6. Fixed Costs

	Butte Eastbound	Other
Tire and brake wear	$0.47	$0.47
Delay	$1.00	$1.00
Fuel for re-acceleration	$0.24	$0.15
Total fixed cost	$1.71	$1.62

Table 7. Summary of Costs

Weigh Stations	Time Lost (in Queue)	Excess Fuel Due to Idling	Operating ($.01217/s)	Total (including fixed)
Butte West	155 s (120 s)	$1.10	$1.89	$4.61
Butte East	187 s (103 s)	$0.94	$2.28	$4.93
Billings West	121 s (95 s)	$0.87	$1.47	$3.96
Billings East	92 s (73 s)	$0.67	$1.12	$3.41
Coutts South	168 s (160 s)	$1.47	$2.04	$5.13
Coutts North	139 s (127 s)	$1.16	$1.69	$4.47

10 FUNDING SOURCES

10.1 Federal and State

The ISTEA bill has set aside some monies for the ITS program for operational tests and early deployment projects. These funds were originally intended for urban areas and are difficult for a rural state like Montana to pursue. However, Montana should still pursue these funds.

With the exception of operational and early deployment projects, ITS projects must compete for funding with other construction projects by proving to be a cost-effective alternative for improving safety and congestion. It is noteworthy that ITS projects, by their nature, are less expensive when built coincident with traditional highway construction (Livesay, 1995). Pavement sensors, for example, are much less expensive when included in the paving process. The following is a list of the different funding programs and program areas under the Statewide Transportation Improvement Program (STIP) with a brief discussion of their constraints relating to ITS projects.

10.1.1 Interstate Maintenance (IM)

These funds are obviously limited to projects on interstates. In addition, reconstruction activities are not an eligible activity when adding capacity by constructing new lanes for single-occupancy vehicles.

10.1.2 National Highway (NH)

These funds are eligible for interstate and principal arterial routes which have been included in the National Highway System (NHS).

10.1.3 Surface Transportation Program (STP)

Projects that improve roads not functionally classified as local or rural minor collectors are eligible for STP funds. In addition, safety, bridge, bicycle and pedestrian facilities, car and van pool, and wetland mitigation projects are eligible.

10.1.4 Congestion Mitigation and Air Quality Improvement Program (CMAQ)

This program funds projects in Clean Air Act non-attainment areas, which improve air quality standards for carbon monoxide, ozone and small particulates. Projects which are eligible for these funds could increase air standards by improving the efficiency of a transportation system, and/or reducing vehicle use or emissions, or travel.

10.1.5 Bridge Replacement and Rehabilitation Program (BR)

This program funds bridge projects. ITS projects are eligible for these funds.

10.1.6 Surface Transportation Program - Hazardous Elimination

Ten percent of STP funds must be used for safety projects. This funding area is eligible for ITS projects which improve safety.

10.1.7 Reconstruction Trust Fund (RTF)

These funds come entirely from state gas tax money. Since this area does not operate on federal funds, there are fewer restrictions on the type of project. ITS projects may be eligible for these funds.

10.1.8 Federal Lands Highways (FLH)

FLH has three funding areas: public land highways, park roads and parkways and Indian reservation roads. ITS projects may be eligible if they improve roads in the three aforementioned areas.

10.1.9 Traffic Safety Bureau Program

Montana receives a grant through the Highway Safety Act of 1966 for administering a Highway Safety Plan (HSP). Approximately ten problem areas are addressed annually which attempt to reduce accidents and their severity. As mentioned previously, because the primary benefit of ITS is safety, ITS projects lend themselves to this funding source.

10.1.10 Aeronautics and Railroad

ITS, being multimodal, does not exclude air and rail modes of transportation. However, ITS user services, as currently defined, do not apply to air or rail transport, except intermodal transfer facilities and rail/road crossing facilities.

10.1.11 Public Transportation

There are several funding areas within the Federal Transit Act. These include capital, planning, elderly and disabled transportation, training, administrative and/or organizational assistance depending on the specific funding category. ITS projects which improve transit system efficiency or improve service to riders are eligible for some categories of the Federal Transit Act.

10.2 Regional and Local

It is difficult to convince local policy makers to take money from road maintenance and use it for other purposes such as ITS. Localities will pay for systems if they see a cost-effective benefit from the system.

10.3 Private and Partnerships

In addition to public funds, the private sector is a potential source of funding. Some systems may be entirely implemented and managed by private industry. These companies will recover their costs through user fees, advertisements in the system, or other means. In the infancy of some technologies, vendors will sometimes loan equipment for a period of time to promote their product, or in exchange for field testing their product.

Some of these systems could be better deployed by a cooperative effort from several public and private entities. There are many funding possibilities. An example of a partnership is H.E.L.P. Inc., an organization funded by user fees, and private and public organizations. The State needs to continue to look to the future and modify the contractual rules to allow and encourage such cooperative partnerships.

11 SCOPE OF WORK FOR PHASE TWO

The purpose of this section is to aid in the development of a request for proposal (RFP) for Phase II of this project, the development of a statewide ITS strategic deployment plan. The "project" discussed in this section refers to Phase II.

11.1 General

The principal purpose of this project is to develop a Statewide Strategic ITS Deployment Plan to guide the implementation of ITS projects on an area-wide scale commensurate with the needs and objectives of Montana's transportation system. The plan should be environmentally sensitive; give full consideration to all modes and intermodal relationships; provide for efficient cost-effective movement of people and goods; and must be fiscally sound. The plan is envisioned to provide transportation policy makers with guidance to deploy, operate, maintain, and plan an ITS program.

Short-listed firms shall develop a detailed scope of work suitable for inclusion in a final contract. At a minimum, the following items should be addressed in the scope of work. The following items should not be considered as either all inclusive or sequentially ordered. Firms should draw from their own experience and expertise in ITS planning to expand on items to be considered. Other items may also emerge based on input received during the first stages of public involvement. As appropriate, proposed work items should be arranged in a logical sequence.

11.2 Components of Project

Plan Development

The approach to developing the Statewide Strategic ITS Deployment Plan taken by each firm may vary depending on firm resources and experience.

Public Involvement

In order to develop a successful program, it is imperative to obtain public input, especially during the user needs identification. Efforts should be made to obtain the views of a wide range of groups, including public and private, and system user and non-user.

Coordination/Cooperation

The degree of coordination should be appropriate to the scale of the transportation problems. The plan must be developed in cooperation and coordination with:

- Metropolitan Planning Organizations (MPOs) and Native American tribal governments for elements within their jurisdiction. This includes cooperatively identifying transportation issues, and incorporating, as appropriate, existing MPO, Urban, Bureau of Indian Affairs and local tribal transportation studies.

- Other ongoing planning efforts involving railroads, transit airports, inland ports and freight terminals, pedestrian and bicycle facilities plans and other intermodal transportation.

- Local governments on land-use and local transportation planning issues; and consider the concerns of local elected officials.

- Planning by other agencies for economic development, recreation and tourism resources.

- Other agencies on natural resource, environmental and energy issues which have substantial effects on transportation actions.

- Agencies carrying out transportation planning for the transportation disadvantaged.

- Private sector organizations affected by and involved in ITS.

The plan must verify the issues and results identified in the following documents and incorporate into the study:

- Assessment of Rural Applications of Advanced Traveler Information Systems (Draft Report); Federal Highway Administration; April 1994;

- TranPlan 21; and

- Status and Applicability of ITS in Montana.

Identify and Define Needs of Montana's Transportation System

By defining needs, the project approach will be in terms of what services need to be provided to the users of the system, not what new technologies can be incorporated into the system. Problems can be identified by defining the existing system, realizing the vision of the ultimate system and comparing the existing with the ultimate system.

A definition of the existing statewide transportation system will establish the composition and available resources of the major system components and is an important early activity. This definition should include all possible information pertaining to the available resources and environment in which it operates, including such information as the system's purpose, physical components and structure (e.g., roads, travelers, buses, rail, etc.), and organizational structure (e.g., operating agencies, funding sources, political and agency jurisdictions, etc.).
Based on analysis of the above system definition, the Consultant will identify present and future user needs for each modal transportation system. Needs will be organized for each

of the modes for each of the identified study regions and analysis corridors. Analysis is not to be project specific, but rather a definition of the type of need and level of needed improvement within defined corridors and regions. It should consider input from resource agencies, tribal governments, local governments, local and regional plans, and various other modal studies.

User Service Plan

This component of the project, the User Service Plan, will:

- Document the system characteristics, problems and opportunities as discussed above.

- Establish, based on these characteristics, problems and opportunities, and what user services need to be provided to the users of the system. The user services identified will fall into one of six areas.

  - Traveler Information Services
  - Traffic Management Services
  - Freight and Fleet Management Services
  - Public Transit Services
  - Emergency Vehicle Management Systems
  - Additional Services

  For these services, consider the short, medium and long-term system needs, keeping in mind the desire to show early benefits, and accomplish long-term user needs by a phasing/building-block process.

- Discuss the goals and objectives of each user service, and the ITS program.

- Determine the benefits of each user service.

Establish Performance Criteria

Performance criteria will be used to determine the success of the program and specific future projects in meeting the user service goals and objectives. The performance criteria may be either quantitative or qualitative. Quantitative criteria will depend on the particular user service, but might include changes in travel time, accidents, or transit schedule reliability. Qualitative measures, such as surveys, assess the attitudes of the people who interact with the system. Performance criteria will be developed for the overall program and each proposed project.

Identify Projects to Pursue

Identify projects to deploy systems which will fulfill the user service needs. Projects may utilize off the shelf equipment, or may be part of operational testing. The following considerations will be made and documented during the evaluation of future projects:

- Restraints of funding and funding analysis;
- Short, medium, and long-term goals and objectives;
- Environmental impacts;
- Operation and maintenance requirements;
- Procurement alternatives. The traditional low-bid procurement process which works well for traditional construction projects does not work well for systems composed of computers, software, communication devices, electronic sensors, and other similar equipment. Procurement alternatives may include:
  - Low Bid
  - Two-Step
  - Design/Build
  - Sole Source
  - System Manager
  - Design/Build/Operate
- Integration of existing components;
- Incorporation of standards;
- Cost/Benefit analysis of each project;
- Performance and reliability of various technologies evaluated against functional requirements; and
- Interactions between systems and system components. In addition, what functions are required and when and where are they required.

Funding Analysis

The plan must be fiscally constrained. That is, projects recommended in the plan must be based on the appropriate funding resources expected to be available throughout the study period. Funding amounts required for the program will be identified and should include deployment, operation, maintenance, and any additional costs for the program. Funding sources will be identified and should include the various ISTEA funding categories: Federal Transit Administration (FTA), Federal Rail Administration (FRA), Federal Aviation Administration (FAA), and Federal Lands Highway funds as well as other federal, state, or local sources. These funding assumptions will be developed by MDT staff.
The fiscal analysis should also explore non-traditional funding alternatives, and their

feasibility, institutional arrangements or legislative actions which would be required. Some examples of non-traditional funding alternatives that may be explored include impact fees, developer financing, negotiated investments, special assessments, private partnerships, etc.

Identify Program Purpose and Organization

The following items need to be addressed by the consultant:

- History of state and national program;
- Program name (e.g. Intelligent Transportation Systems, Advanced Transportation Systems, or Advanced Integrated Transportation Systems);
- Organizational location of the program within MDT and size of staff;
- Interdepartmental coordination issues;
- Intra departmental coordination issues;
- Coordination with programs both within and outside of MDT;
- Responsibilities of the various organizational components;
- Size of the program;
- Local ITS chapter;
- Rocky Mountain ITS chapter; and
- Ongoing planning and public involvement.

Components of Statewide Strategic ITS Plan

It is envisioned that the Montana Statewide Strategic ITS Plan will provide a policy framework for project selection and resource allocation decisions within the Department. Components of the plan are expected to include:

- Set of projects to pursue by ITS category;
- Time line including short, medium and long-term program and plan deployment;
- Performance criteria for each project and the overall program;
- User service plan;

- Process for ongoing program planning and public involvement; and
- The Montana Statewide Strategic ITS Deployment plan.

12 CONCLUSION

The principal objective of this study was to accumulate information pertinent to ITS in Montana, which will aid in consolidating and focusing MDT's position on ITS. The following tasks worked toward this goal:

- Inform and identify concerns of Montana's transportation stakeholders;
- Identify needs and potential benefits of ITS in Montana;
- Identify existing systems and related activities in Montana and the nation;
- Identify potential systems for Montana;
- Identify potential funding sources; and
- Develop a Scope of Work for Phase II.

Montana's transportation stakeholders were contacted to inform them of ITS, discuss ITS activities in Montana, and receive feedback concerning their views and concerns about ITS. The groups contacted most liked technologies which improved safety such as collision warning and construction zone safety improvements. Most groups were in favor of a statewide ITS deployment plan. However, they had many concerns. The biggest concerns dealt with funding and cost issues.

Nationally, The benefits of Intelligent Transportation Systems have been identified as follows:

- Improve safety;
- Reduce congestion;
- Improve mobility;
- Reduce environmental impacts;
- Increase energy efficiency; and
- Improve economic production.

All of these areas are of concern to Montana's transportation system; however, the primary benefit to Montana is improved safety.

The application of ITS technology is not new to Montana. The existing and planned ITS technologies in Montana are:

- SCAN remote weather monitoring system;
- Advanced traffic control in metropolitan areas;
- Automated data collection;
- Weigh-in-Motion (WIM);
- Heavy-Vehicle Electronic License Plate (H.E.L.P.) Inc.;
- Interactive traveler information booths;
- Possible of ride matching program in the Bitterroot valley; and
- Testing of onboard computers for law enforcement vehicles.

There are many ITS technologies which are applicable to Montana. Below is a list of potential ITS technologies identified in this report.

- Data Collection
- Automated Inspection
- Collision Warning/Avoidance
- In-Vehicle Signing
- Animal Collision
- Slow-moving Vehicle Warning
- Slippery Conditions Warning
- Intersection Collision Warning
- Active Logo Signing System
- Intermodal Transfer Facilities
- Robotics in Construction & Maintenance
- Electronic Clearance
- Mayday
- Vision Enhancement
- Work Zone Traffic Control
- Emissions Testing and Mitigation
- Incident Management
- Safe Speed System
- Advanced Tourist Information
- In-Vehicle Navigation
- Advanced Public Transit Systems

ITS projects are eligible for funding from many sources. In funding these projects it is important to recognize that: (a) ITS projects generally must compete with any other transportation improvement project based on costs and benefits, and (b) because of the nature of ITS projects, they are generally less expensive when built coincident with traditional road construction projects.

TranPlan 21 and most stakeholders are in favor of an active ITS state program in Montana. This study recommends that MDT continue with the development of such a program. Recommendations for the success of the ITS program are summarized as follows:

1) Develop an ITS strategic plan for Montana.

2) Organize and staff an ITS unit.

3) Promote ITS at the community and state levels through education.

4) Stay abreast with privacy, liability, reliability and other institutional issues.

5) Ensure Reliability and Quality of Investment by:

- Employing an ITS coordinator knowledgeable of ITS products;
- Ensuring that products conform to national standards; and
- Developing specifications and standards where they do not exist nationally.

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