ASSESSING NEEDS AND IDENTIFYING OPPORTUNITIES FOR ITS APPLICATIONS IN CALIFORNIA'S NATIONAL PARKS

Technical Memorandum 4: Developing Measures of Effectiveness
for Evaluating ITS in National Parks

By

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1. INTRODUCTION

Increasing travel demand, combined with limited room for infrastructure expansion, has prompted the need for innovative solutions to transportation challenges. Intelligent transportation systems (ITS) offer many promising solutions. In an urban setting, ITS improves the efficiency and throughput of the roadway without building more capacity. In rural areas, ITS deployments focusing on real-time traveler information and incident management are enhancing the safety of travelers. By definition, intelligent transportation systems collect, store, process, and distribute information relating to the movement of people and goods (1). ITS deployments may impact the vehicle, the user, the infrastructure, and the communication system and offer a broad array of benefits to all users and operators of the transportation system. ITS technologies are typically not deployed as individual elements because they are more effective as part of an integrated system that involves many different components. This, along with the nature of the advanced technologies, makes ITS a significant investment in any setting.

ITS has been used in various forms to improve the safety and efficiency of transportation systems throughout the world. Typically, ITS applications and their corresponding evaluations have focused on urban deployments, where benefits are the most apparent. As the benefits of these deployments are being recognized through field operational tests and evaluations, ITS applications are being used in many different regions, domestically and internationally, and are no longer confined to urban areas. As the use of ITS becomes more widespread, one of the areas that shows promising benefits is national parks and their surrounding gateway communities.

One of the biggest challenges with ITS implementation is recognizing and appreciating the benefits that ITS can provide. Limited resources, combined with the increasing demand for infrastructure improvements, have increased the pressure on agencies to prove the effectiveness of any ITS deployment. For this reason, evaluation is an essential component of ITS implementation to quantify the benefits of deployment and relate them to expenditures. Currently, research related to evaluation strategies and the corresponding measures of effectiveness (MOEs) have focused primarily on urban settings. Presently, there is limited experience with ITS used in a national park setting, let alone evaluation strategies and specific MOEs.

California has many national parks units that serve visitors from around the world. The demand to experience these precious resources is increasing every year, resulting in an increased negative impact on the transportation system with potential negative effects on the resources within each park. Additionally, many of these parks are very close to densely-populated urban areas and the transportation impacts can be seen outside the park boundaries.

For these reasons, the California Department of Transportation (Caltrans) Division of Research and Innovation sponsored a research project to explore how ITS can help California's national parks. The first phase of the project analyzed two parks – Golden Gate National Recreation Area (GGNRA) and Sequoia and Kings Canyon National Parks (SEKI) – on a case study basis, with respect to developing suitable ITS themes. This phase included documentation that would help the case study parks and other California parks consider ITS solutions to address their transportation challenges.

Phase 2 of this research effort is further investigating the role of ITS in California's national parks, with the goal of advancing toward ITS demonstration and evaluation. Specific tasks include developing an outreach tool for Caltrans districts and national parks in California to show the potential for ITS applications, exploring how the National ITS Architecture works with national parks, and implementing and beginning the evaluation of ITS early-winner projects at GGNRA and SEKI.

To successfully complete the evaluation task, research involving evaluation plans and the associated performance measures is conducted and documented in the following report. This study explores possible MOEs and combinations of MOEs that may be useful in a national park setting. The primary purpose of this research was to use the ITS themes and early-winner projects selected for Phase 2 of this project as the basis for developing and selecting appropriate and applicable measures for successfully evaluating ITS deployments in California national parks. The research, however, is intended to have applicability to other ITS deployments in national parks throughout the United States and to be an important documentation of potential benefits of ITS in national parks.

To reach this goal, this paper will first examine the components of an evaluation plan and some existing measures of effectiveness currently in use in urban, rural and international settings. Next, the unique characteristics of national parks that may affect the goals, objectives and MOEs of ITS deployment will be outlined. Existing ITS deployments and evaluation activities within national parks will be reviewed for applicability. The following chapters present specific goals and objectives for ITS in national parks, as well as data collection requirements and baseline data availability considerations. The report concludes with two examples of how the methods in this report may be applied to a specific ITS deployment, a summary of this report, and recommendations for further research regarding ITS deployments and evaluations in national parks.

2. EVALUATION PLAN

Evaluation is an important part of the ITS deployment process, providing enhanced quality and validating the benefits of deployment. It is used to understand the impacts of an ITS system, quantify the associated benefits and optimize the existing system's operation and design. Evaluation is an on-going process and may consist of multiple phases. It is important to identify explicit project goals and identify priorities so that the limited resources are utilized to their maximum potential. Determining how well the system meets a designated budget and achieves the anticipated performance on schedule is another component of the evaluation process. An evaluation plan is an essential component to the deployment of ITS and consideration should be given before implementation, in the early planning stages.

There are two main methods of evaluation that can be used independently or together to achieve the anticipated results. The goal-oriented method defines goals and objectives and sets up specific measures to evaluate how well the end project met its original, stated goals. An economic analysis method examines the cost-efficient ways to achieve a goal. Specifically, it examines whether the investment in ITS to achieve a goal is economically beneficial and how the rate of return on investment compares to that of other projects (i.e. infrastructure expansion). Each method has a process that incorporates data collection followed by statistical analysis and/or modeling. The results can then be used for cost and benefit comparisons (2).

An evaluation plan consists of many different parts, including: goals and objectives, measures of effectiveness, data availability and collection, as well as some additional factors. Each part contributes to the overall success of the evaluation. A brief discussion of each of these components follows.

2.1. Goals and Objectives

The most effective evaluation plan will evaluate the function of an ITS system component over its entire life cycle and will be based on a clear identification of goals and objectives defined by stakeholders and independent evaluators (3). Stated goals and objectives are an important element of the evaluation process. A goal is a broad purpose or statement of general intention. Objectives are more precise and narrower in scope to provide a measurable means to reach a specified goal. Large numbers of goals require more specific measurements and reporting, which result in increased funding requirements. Specific goal areas that incorporate many smaller, individual goals are more economical and can appropriately address many of the critical areas. Providing a few solid goal areas that have broad applicability to many different systems is the starting point for a standardized evaluation framework.

2.2. Measures of Effectiveness

Funding allocations and budgets are based upon the achievement of goals. Each goal requires periodic measurement and reporting. Additionally, there needs to be means to adequately tie the goals to the measurement of its success and the anticipated benefits. A measure of effectiveness is a quantitative parameter used to measure the performance of a system or a facility that contributes to its constant development and improvement when monitored. An effective MOE should evaluate how well the system works in a way that is simple, logical and understandable and be able to track trends over time. Data collection efforts related to a MOE should also be easy and economical. There are some guidelines that are important to the development of effective MOEs, although it may not be possible to incorporate all of the criteria into every MOE. Some of these guidelines include:

- relevance to ITS goals and objectives,
- acceptance by stakeholders,
- clear and specific relationship to objective,
- simple and understandable,
- measurable and quantifiable,
- sensitive and applicable,
- non-redundant, and
- appropriately detailed (3).

It is essential to look at the whole system and a combination of MOEs to determine the benefits and impacts of ITS technologies. MOEs may be classified as quantitative or qualitative. Operational performance, crash data, delay, and environmental considerations are quantitative, whereas customer satisfaction ratings and system management ratings are qualitative (4). Both have applications and can provide valuable insight. Typically, it is preferable to have a MOE that reflects quantifiable benefits, but qualitative benefits can also be valuable and support the outcome of previous studies and contribute to the evaluation of the system as a whole. Determining monetary values for associated benefits, such as customer satisfaction, can be difficult. It is important to recognize that even benefits that cannot be assigned a dollar value may still offer significant advantages to the user.

A good MOE should be structured to address a variety of goals and objectives, as each additional MOE requires more resources, time and money. A successful evaluation plan typically is a compromise between many interdependent MOEs. Many of the MOEs overlap and may be used to evaluate more than one goal area.

2.3. Data Collection

The scope of the evaluation process is initially very large, due to the wide range of benefits that can potentially be gained from ITS deployments. There are many potential MOEs that may be used, but they are not all created equally. Additional criteria, including the availability of existing baseline data and the level of difficulty for future data collection efforts (including the time and cost investment of collecting the required data), and the ability of the MOE to quantify benefits related to the specific goal areas should be considered for the development and selection of MOEs.

The evaluation process is often an afterthought to implementation. As a result, the project budget typically does not include costs for evaluation and the necessary baseline data is often not available. An established framework that outlines specific guidelines for the type of data that needs to be collected prior to implementation is useful in all stages of the planning process.

2.4. Additional Factors

Some additional factors that influence the effectiveness of an evaluation plan include the scale of analysis, impacted groups and the evaluation time frame. When looking at the cost/benefit analysis there are two different levels to be considered: system-wide versus individual benefits. ITS components often have considerable overlap and evaluating the benefits of the whole system of ITS is more effective in assessing the outcome of an investment and, on a larger scale, for future decision-making.

The groups of people that are impacted by an ITS system are not limited to users of the system; non-users, such as residents, property owners, public agencies, Departments of Transportation and private sector interests, are also affected on various levels. Additional impacts can be seen on the transportation infrastructure and the environment.

Lastly, a time frame designation is an important component to the evaluation plan. Some impacts and benefits may be visible right away, while others may take years before showing quantifiable benefits. The appropriate time frame must be determined early on, so there is an understanding of the benefits and when they can be expected to occur. This timeline also influences the choice of appropriate comparisons and the types of analysis to be considered in an evaluation plan.

The complexity of evaluation can be attributed to the high number of internal and external variables that affect ITS components. ITS projects include multiple components and it may be difficult to isolate the benefits of each component. Additionally, the complexity of the evaluation is highly dependent on the intended end use of the evaluation results. A sophisticated framework may be needed for a detailed economic analysis, whereas a less complex plan may be used to prioritize ITS projects or track annual progress towards specified goals (2).

3. REVIEW OF ITS MEASURES OF EFFECTIVENESS

Numerous factors affect the ability of an ITS technology's performance to be measured, including the goal of the technology, the ability to collect the data, the technology's intended performance and other system limitations. After these factors have been considered, appropriate performance measures, also called measures of effectiveness (MOEs), are selected. These measures typically look at the performance of the affected transportation networks (e.g. improvement in system capacity), rather than simply the performance of the individual ITS technology (e.g. number of system failures).

Due to limited funding, difficulty in accumulating appropriate data and the lack of existing baseline data, there has been a focus on several measures that are effective in representing the goals and objectives of the entire ITS program on a national level. In addition to these measures that are determined from the specific goals, surrogate measures have been developed that have important correlations to these MOEs but may be more easily quantified, based on ease of data collection or other factors.

This chapter reviews these existing measures of effectiveness that are used in ITS evaluations throughout the world. The MOEs in this section have been divided into national, urban, rural, and international MOEs to discuss the similarities and differences of ITS applications and evaluations in these different settings. Each area has different ITS deployments and corresponding evaluations that have been successful on various levels. Most of the past research has been conducted in these areas. The end goal of this section is to analyze the level of transferability between these areas and national parks, and identify which existing MOEs can be applied or modified for use in a national park setting.

3.1. National ITS Measures of Effectiveness

The diverse, dynamic nature of ITS technologies presents significant challenges when evaluating their uses and benefits. Some of the most common themes when looking at evaluations and measures of effectiveness are related to safety, but there are many other measures that have been developed and used successfully in evaluating the benefits of an ITS system.

In an effort to assist the ITS community and develop a standardized ITS program, the U.S. Department of Transportation (DOT) established the Joint Program Office (JPO) in 1994. In 1996, as one of its tasks, the JPO jointly with ITS America established a National ITS Program Plan (5). In this plan, six national ITS goals were proposed that have become the basis for most national ITS evaluation criteria. These six goals and subsequent objectives are shown below in Table 3-1.

Table 3-1: National ITS Goals and Objectives

Goal Area	Goal Statement	Objectives
Safety	Improve the safety of the Nation's surface transportation system	▪ Reduce the frequency of crashes ▪ Reduce the severity of crashes
Capacity	Increase the operational efficiency of the surface transportation system	▪ Increase the capacity of the transportation system ▪ Reduce congestion due to incidents ▪ Improve transportation customer service
Environment	Reduce energy and environmental costs associated with traffic congestion	▪ Reduce harmful emissions per unit of travel ▪ Reduce energy consumption per unit of travel ▪ Reduce new transportation right-of-way requirements
Productivity	Enhance present and future productivity	▪ Reduce costs of fleet operators, operating agencies, and individuals ▪ Reduce travel time ▪ Improve transportation system management and planning
Mobility and Customer Satisfaction	Enhance the personal mobility and the convenience and comfort of the surface transportation system	▪ Enhance traveler security ▪ Reduce travel stress ▪ Improve access to transportation
	Create an environment in which the development and deployment of ITS can flourish	▪ Support the establishment of significant U.S.-based industry for hardware, software, and services

The JPO then conducted a cost-benefit analysis, in which they further identified several measures of effectiveness to evaluate the performance of ITS services in each of the six goal areas. The measures became known as the "Few Good Measures" and are intended to be a cost-effective tool to track performance on a yearly basis and gauge the effects and impacts of ITS. The following is an overview of the six goal areas (6).

- **Safety**: A critical objective of the transportation system is to provide a safe environment for travel. Many ITS systems aim to minimize the risk of crash occurrence. Some of the specific goal areas are focused on reducing the severity and number of crashes. The corresponding MOEs used to measure the performance and benefits include the total crash rate and the split between fatal and injury crash rates. Related measures including vehicle speeds, speed variability, or changes in the number of traffic safety violations may also be used (6).
- **Mobility**: Improving mobility by reducing delay and travel time is another goal of ITS. Some of the measures commonly used include the amount of delay time and the variability in travel time per vehicle. Delay is typically measured in time of delay per vehicle. This concept may also be used in transit and freight applications (6).

- **Capacity/Throughput**: Highway capacity can be defined by the "maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a given point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions" (7). Capacity is usually measured when ideal conditions are present; effective capacity changes with weather conditions, road conditions, and additional factors such as congestion and incidents. Throughput is defined as the number of persons, goods, or vehicles traversing a roadway section or network per unit time. Under certain conditions, it may reflect the maximum number of travelers that a transportation system can handle. Throughput is more easily measured than effective capacity and can be used as a surrogate measure evaluating an ITS project (6).

- **Productivity**: ITS implementations can reduce operating costs and allow productivity improvements. Compared to many other transportation improvements, such as new roadway construction, ITS improvements often cost less, not only for initial deployment, but also for on-going maintenance. Another cost-saving benefit is the use of ITS to acquire and archive data for purposes of information exchange between agencies. The measure of effectiveness for this goal area is cost savings as a result of implementing ITS (6).

- **Environmental**: The air quality and energy impacts of ITS services are very important considerations. Decreases in emission levels and fuel consumption have been identified as measures of effectiveness for this goal area. Specific measures of effectiveness include emission levels, fuel use and fuel economy (6).

- **Customer Satisfaction**: Another important benefit of ITS projects is the assurance that traveler expectations are met. Customer satisfaction reflects users' expectations and experiences in relation to a service or product. The central question in a customer satisfaction evaluation is, "Does the product deliver sufficient value (or benefits) in exchange for the customer's investment, whether the investment is measured in money or time?" Although satisfaction is difficult to measure directly, measures related to satisfaction can be observed, including amount of travel in various modes, mode choices, and the quality of service, as well as the volume of complaints and/or compliments received by the service provider (6).

  In addition to customer satisfaction, it is necessary to evaluate the satisfaction of the transportation system provider or manager. The satisfaction of the transportation provider is directly related to the appropriate distribution of limited funding and the assessment of impacts from increased communication between and coordination of systems. A survey of transportation management officials before and after a specific ITS system has been implemented can be useful in determining qualitative benefits to management officials (6).

From these six goal areas, specific evaluation measures were designated as a "few good measures". They include:

- crashes,
- fatalities,
- travel time,

- throughput,
- user satisfaction, and
- cost.

These specific measures have been tracked yearly and documented in a series of reports. Although these classifications are advocated by ITS JPO and are the most common in use, additional categories do exist for grouping MOEs. One additional study outlined a breakdown of MOEs based on their functional purpose and use (3). These include the following.

- **Operational MOEs** are used to assess the operational characteristics of transportation facilities such as freeways and arterials. Some of these include flow, average speed, average travel time, number of stops, intersection delay, queue length and volume to capacity ratio (3).
- **Planning MOEs** are used in planning operations of systems. These include acceptable delay; congestion index, which is the ratio of total freeway delay to the freeway vehicle miles traveled (VMT); travel speed; and travel speed index, which is the ratio of travel speed on a freeway to the free flow travel speed (3).
- **Environmental MOEs** focus on the environmental impacts of transportation, and include vehicle emissions monitoring and fuel consumption (3).
- **Economic MOEs** include the cost of travel from origin to destination, maintenance and construction expenditures per VMT, economic costs of crashes and time lost during incidents (3).
- **Design MOEs** include free flow speed, density and intersection level of service (LOS) (3).
- **System MOEs** focus on the entire system to evaluate its effectiveness in terms of mobility, accessibility and utilization (3).
- **Mobility MOEs** include origin-destination travel times, average speed, VMT by congestion, delay due to congestion, Level of Service (LOS) and person miles of travel (3).
- **Safety MOEs** are defined by the total overall accidents and the breakdown of severity into fatalities, injuries, and property damage. All safety measures are compared and analyzed with consistent units, typically normalized over VMT (8).

The goals and objectives developed at various levels have been strong influencing factors in the development of these different MOEs categories. A standardized set of measures that can be applied to a wide variety of projects is beneficial, and JPO's few good measures were the first efforts on a national level. They serve as a good starting point for identifying potential MOEs, but as deployments and evaluations of ITS increase, these categories may change to meet the dynamic needs of ITS and the transportation network.

3.2. Urban ITS Measures of Effectiveness

The national measures of effectiveness were created with urban areas in mind, since the first ITS applications were envisioned as solutions to urban transportation challenges. As a result, this section highlights applicable case studies of some urban deployments that utilize the existing national MOEs as part of the evaluation plan.

A few specific cities were designated by the JPO as model deployment initiatives (MDI) of ITS. The Metropolitan MDI (MMDI) represents some specialized urban case studies. These studies had unique goals and additional objectives that required modifications from the Federal guidelines. The three primary objectives of MMDI were:

- documenting the institutional benefits that enabled these sites to be selected, and methods for successfully addressing new issues during the model deployment development and implementation process;
- determining the incremental effects of increasing ITS deployment levels, especially traveler information systems, on some key transportation system attributes, including customer satisfaction, traffic flow, travel demand and safety; and
- conducting an economic analysis of costs versus benefits of ITS deployment (9).

Four cities – Seattle, Phoenix, San Antonio and New York – were selected to demonstrate the benefits of a coordinated ITS system by providing real-life examples of technology's potential in urban areas (10). A significant component of the MDI was to conduct rigorous evaluations to demonstrate the benefits of an integrated metropolitan intelligent transportation infrastructure. One of the primary goals of the MDI evaluation was to test the hypothesis stated as "the whole is greater than the sum of the parts." The evaluations of these deployments are based on the national objectives set by JPO and the "few good measures" discussed in the previous section (9). Regionally, there are significant differences in the magnitude of benefits, due to pre-existing traffic/transportation system characteristics, implementation details and the evaluation methods used.

The U.S. Department of Transportation defined nine metropolitan ITS infrastructure components: transit management, freeway management, traffic signal control, railroad grade crossing safety, emergency management services, incident management, electronic toll collection, electronic fare payment, and regional multimodal traveler information (9)

Seattle's ITS integration efforts focused on making transportation more efficient by sharing traffic information between agencies, providing real-time traveler information to the public, and giving prioritized movement to emergency vehicles. The Washington State Department of Transportation focused on the coordination of traffic signals and ramp meters so that jurisdictional boundaries did not affect travelers. Additionally, the Internet was designated as a tool for sharing information between public agencies and the traveling public. The SmartCard is a regional electronic fare system that utilizes a single card, to simplify the transit rider experience. The deployment focused on the importance of incremental steps, beginning with information sharing and continuing towards the ultimate goal of integrated control of the ITS system (11).

Phoenix partnered with all 18 major cities in the Phoenix metropolitan area to develop the AZTech program. This program incorporates vehicle detection loop detectors and sensors to send traffic signal information over fiber-optic communication lines. All of the information is processed at a central traveler information database and then distributed to the appropriate agencies and traveling public. The benefits include increased communications between departments managing area roadways, better signal timing coordination between municipalities, improved coordination of road closure projects, traffic signal system upgrades, and a single data source for real-time traffic data. Specifically, the cross-jurisdictional traffic signal timings lead to increased speeds and reductions in vehicle stops, fuel consumption and crash risks (11).

The ITS deployments in San Antonio included in-vehicle navigation units on paratransit vehicles, advanced warning to avoid railroad delays and traffic management along the Medical Center corridor. Radars placed at selected locations along the railroad tracks detect the presence, speed and length of trains before they approach the crossing. This information is then processed and distributed to a coordinated traffic management system that can further disseminate the information to the public, via variable message signs. Traffic management along the Medical Center corridor was integrated with the freeway and parallel arterial streets. Simulation models showed the decrease in delay could improve by up to 20 percent during major incidents (11).

New York City is part of a much larger metropolitan area that includes additional parts of New York, New Jersey and Connecticut. The ITS deployment consisted of many region-wide traveler information systems, including ones that provide basic traffic and transit information, a regional transit itinerary planning system that provides route guidance, as well as a personalized traveler system that provides customized, proactive travel information to subscribers. Providing an integrated traveler information system throughout the region is beneficial to many transportation agencies as well as the traveling public (10).

The three MDI objectives cited earlier, combined with the national ITS program plan objectives and the few good measures developed by the U.S. DOT, form the basic evaluation strategy of these deployments. These interrelated evaluation areas include the following (9).

- **Safety.** This study area focused on crashes and fatalities, with an interest on the particular benefits of safety. There was also a focus on data collection for assessing the safety of the ITS infrastructure.
- **Operational efficiency**. This study area primarily focused on throughput and travel time, but also included capacity- and efficiency-related goals.
- **Customer satisfaction.** This study area evaluated the satisfaction of travelers, traffic management system operators, and business community leaders with ITS deployment and addressed the goals of improving convenience and comfort.
- **Energy and emissions**. This study area measured fuel consumption and changes in travel-related pollution as a result of ITS projects and their integration.
- **Institutional benefits.** This study area addressed both the public and private involvement in MMDI. The study tracked institutional changes made over time to address non-technical barriers. It also identified and evaluated public sector institutional structures associated with the deployment and integration of ITS at Metropolitan MDI sites.
- **Benefit-cost.** This study area used the benefits that have been determined from the other five studies, as well as the cost of the component, to carry out a benefit-cost analysis.

A common theme throughout each of these cities is the focus on integration. The integration may be incorporated through shared infrastructure, shared information or coordinated control. Although this integration has many benefits, fitting goal areas and MOEs to evaluate system wide deployments can be challenging. The additional areas included as part of the evaluation strategy were used to help alleviate some of these challenges.

3.3. Rural ITS Measures of Effectiveness

The measured success of ITS applications in urban settings has prompted the investigation of their application in rural settings. Rural agencies are interested in using ITS to address increasing travel demands and high fatality rates, but limited funding resources have challenged the widespread integration of ITS into rural systems. This contributes to the increased need for evaluation to justify benefits. It is difficult to justify the presence of these systems in areas that have relatively low traveler demand and where ITS implementation can cost more due to lack of an adequate power and communications infrastructure. The evaluation of ITS applications is therefore of particular importance in these rural applications due to the necessity of good performance ratings and positive cost-benefit ratios to justify the investments.

The uses for ITS in rural settings differ from those in urban settings; therefore, different measures are necessary to look at the performance of deployment. The specific goals of ITS in rural areas can be split into seven different categories:

- emergency services,
- tourism and travel,
- traffic management,
- rural transit and mobility,
- crash prevention and security,
- operations and maintenance, and
- surface transportation and weather (12).

Emergency services are represented by the various agencies that respond to an individual incident. An incident can be anything from an individual collision to a natural disaster that requires services from the police, fire, medical, and tow truck response teams. In rural settings, high incident detection and response times are of particular concern.

ITS benefits can be seen and measured in traffic management and safety in similar methods as mentioned above in urban settings, but there are some differences based on the characteristics of rural roadways. Construction delays, as well as increased congestion due to local attractions and special events, are intensified due to a lack of alternate routes.

The severity of crashes in rural settings is often higher due to higher speeds, outdated geometric designs, and vehicle collisions with roadside objects or wildlife. ITS applications affecting the driver, vehicle and roadway have many potential benefits and can enhance the efficiency of the rural transportation system.

The high number of rural roadway miles and limited funding sources can also make operations and maintenance practices challenging. Weather conditions, both expected and unexpected, pose problems on every roadway, but rural travelers face variable terrain, abrupt condition changes and longer emergency response times. ITS that utilizes real-time traveler information can positively impact traveler decisions and route choices.

Based on these characteristics various ITS strategies have been deployed to address these issues. Some of the commonly used measures of effectiveness are reduced emergency response time, reduced incident and detection times, reduced severity and number of overall crash rates, decreased delay times, positive economic impacts, usage of en-route traveler information, and agency and traveler satisfaction (13).

Two particular field operational tests (FOTs) investigated ITS applications in rural tourism areas: Branson, Missouri and the Interstate 40 Corridor in northern Arizona. Tourism is a major contributor to the regional and state economies in these two locations and, as a result, enhanced visitor experience and return visits are a significant motivating factor for improved traveler information systems.

Branson attracts over 6 million visitors each year to various outdoor recreation activities, entertainment theatres, and outlet malls. The regional traveler information system in place, TRIP, includes comprehensive information on tourist attractions, weather, traffic, and road construction.

Interstate 40 crosses northern Arizona and serves as the primary access to the Grand Canyon and over 20 other major national parks, monuments and recreation areas. Particular challenges related to this corridor include: as much as 40 percent commercial vehicle traffic, adverse and changing weather conditions, and significant changes in elevation. ITS deployment on this corridor collects, processes, and disseminates weather and road conditions as well as other traveler information.

Both Branson and the I-40 Corridor have the following ITS components in place:

- changeable message signs,
- interactive voice response telephone lines,
- kiosks, and
- websites.

Additionally, Branson utilizes highway advisory radio for information dissemination. The I-40 Corridor has two different sets of kiosks and websites: one set is maintained by the Arizona DOT, while the other is managed by a partnering private agency. Both areas plan to expand, upgrade, and integrate the existing deployments into nearby, surrounding cities to enhance the efficiency of the system.

The evaluation plan that was established for these two FOT case studies identified five specific areas of focus including mobility, access, congestion, economic impact, and safety (14). As mentioned in the previous section, collecting all of the available information needed for evaluation is expensive and time-consuming. A few good measures have been developed for each of the goal areas. In some cases, these measures are difficult to quantify or to obtain the required data in a cost-effective, timely manner. Therefore, surrogate measures were developed that fit into the specified evaluation time frame and could be used to effectively measure the effectiveness of the ITS deployment. Table 3-2 shows the goal areas and subsequent MOEs developed for Branson, MO and the I-40 Arizona Corridor.

Table 3-2: MOEs in Rural Tourism Areas

Goal Area	Few Good Measures	Surrogate Measures
Mobility	▪ Travel time ▪ Ease of travel ▪ Tourist traveler satisfaction	▪ Proportion of surveyed respondents using an ITS component who reported that information saved time ▪ Proportion of surveyed respondents that agree or strongly agree on ease of travel ▪ Perceived satisfaction of total travel experience ▪ Number of stops for directions
Access	▪ Knowledge of travel options	▪ Percentage of tourists indicating use of an alternative route ▪ Number of attractions visited ▪ Percentage of tourists indicating a change in attractions visited ▪ Percentage of tourists indicating that they visited attractions they had not previously known about because of information obtained through ITS
Congestion	▪ Number and nature of delays ▪ Level of service (LOS)	▪ Reported number and severity of delays ▪ Percentage of tourists indicating that congestion was avoided ▪ Prior knowledge of traffic problems ▪ Traffic volume and throughput ▪ Average travel speed ▪ Number of accidents ▪ Incident response time
Economic Impact	▪ Increased visitation ▪ Tourism revenue ▪ Increased awareness of alternative attractions	▪ Duration of stay (overnights) ▪ Estimated expenditures throughout stay ▪ Intent to return ▪ Willingness to utilize information outlets for fee ▪ Utilization of information outlets
Safety	▪ Safety ▪ Injuries, fatalities	▪ The amount of information regarding safety that is available before and after implementation ▪ The percentage of travelers detouring as a result of traveler advisories displayed on roadside variable message signs ▪ Perception of safety

Source: (14)

Mobility on the study corridors is critical to the anticipated success of the roadways. This area is closely related to both expected and unexpected sources of congestion. Minimizing the amount of delay, as well as the overall travel time between destinations is important. These factors are important to tourists, local users, and the commercial vehicles that utilize these roads.

The different categories are representative of the unique needs of these rural areas. Of particular importance is the improved access when travelers are aware of alternate options, such as different modes or routes, or completely different attractions. This can be measured by the knowledge of traveler options and their visitor experience enhancement based on the information provided. In an urban setting, access points are located much closer together and access is not such a high priority.

Congestion in rural settings is often associated with special events or specific attractions that have limited space available, as opposed to everyday commuter traffic. Also, congestion related to incidents or construction zones may be intensified by the difficulty in finding and using alternate routes. Typical measures that reflect this difference include the duration, location and nature of delay and the level of service of the roadway.

Economic impact is a goal unique to rural situations and is related to the potential increased patronage of attractions, resulting from improved information distribution. More time may be spent in an area due to an increased awareness of alternate attractions, and there may also be an increased likelihood of returning to the area. The percentage of increased visitation, incremental increases in tourism revenue and the increased awareness of alternate attractions are typical measures for this specific goal area.

Lastly, safety is a critical goal that is affected by mobility, congestion, and other additional factors. In rural areas, emphasis on safety is a good way to get ITS in place because of the visible, measurable benefits that can be seen from deployment. Measures of effectiveness related to safety are the same as mentioned earlier, but in rural settings, specific attention may be applied to incident management, due to the longer detection and response time of emergency vehicles, and the benefits of interagency coordination.

The evaluation plans for the rural FOTs focused on the ability to affect the travel behavior of tourists, with an emphasis placed on accurate real-time data to indicate changes in the road conditions, congestion and the location of incidents (14).

Many of the Federal guidelines apply to many of the goals and objectives of rural and tourism areas. Additional challenges, such as limited funding and low traveler demand, may make it more difficult to justify ITS deployments. Placing emphasis on one strong area, such as safety, where the benefits are highly visible, may provide the necessary validation for ITS implementation.

3.4. International ITS Measures of Effectiveness

Many countries throughout the world have deployed ITS to address their transportation-related problems. Prominent systems in Japan, Spain, Australia, and Finland have been developed and deployed. Methodologies for the evaluation of these different systems have also been developed. The issues being addressed in these countries are similar to those in the United States: traffic congestion with limited space for new roadways, safety and environmental concerns. Many of these countries utilize transit and alternate modes of transportation more readily and frequently than the United States, contributing to a higher focus on transit management and ITS for real-time transit arrival information.

Japan has been a leader in worldwide ITS implementation. The nine key deployment areas include: advances in navigation systems, electronic toll collection systems, assistance for safe driving, optimization of traffic management, increasing efficiency of road management, support for public transport, increasing efficiency in commercial vehicle operations, support for pedestrians and support for emergency vehicles. Currently there is a four-phase program in place outlining the continued deployment and integration into a nationwide system, beginning with traveler information systems and in-vehicle navigational units in the year 2000 and continuing to a full-scale advanced information and telecommunications infrastructure beyond 2010 (15).

In Spain, ITS applications related to advanced public transportation systems include automatic train protection, driverless operations and intelligent ticketing systems. The associated benefits are enhanced safety and security, reduction in operating costs, shorter travel and waiting times, an increased use of public transportation, and positive environmental effects. Measures of effectiveness can be directly related to these benefits (16).

The development of ITS internationally includes effective evaluation plans to measure the overall performance of the road network. Performance measures are a useful tool for making informed policy decisions at a regional and national level, as well as an effective means of monitoring changes and tracking the outcome of decisions. Austroads is an association of Australia and New Zealand road transport and traffic authorities that oversees the collection of transportation performance information. One Austroads study recommends that the evaluation should be focused on the performance of the transportation system, not the individual ITS deployments. The core performance measures can be categorized into economical, social, safety and environment (17). Further measures by Austroads are shown below in Table 3-3.

Table 3-3: Austroads MOEs

Goal Area	Measures of Effectiveness
Road safety	▪ Road fatalities (population basis)
Registration and licensing	▪ User transaction efficiency
Road construction and maintenance	▪ Road maintenance effectiveness ▪ Smooth travel exposure
Environmental	▪ Traffic noise exposure ▪ Greenhouse gas emissions
Program/project assessment	▪ Return on construction expenditure
Travel time	▪ Actual travel speed ▪ Congestion indicator
Lane occupancy rate	▪ Lane occupancy rate (persons) ▪ Lane occupancy rate (freight)
User satisfaction index	▪ User satisfaction index

Source: (18)

The Finnish government sponsored the development of guidelines for evaluation to promote knowledge, compare across ITS projects, and compare ITS to non-ITS transportation solutions. Additional focus was given to the incorporation of multi-criteria measures to include qualitative and quantitative assessment of benefits. The measures of effectiveness noted for some of the common ITS goals and objectives in Europe were separated into transportation networks and costs, accessibility, travel time and its predictability, safety, valuation and comfort, and environmental impacts (19). Numerous methodologies were discussed, but special attention was given to those that had readily available data and encompassed more than one objective. Three important criteria for the development of effective performance measures include:

- validity, or the extent to which the measure is diagnostic for policy goals being studied;
- reliability, or the reproducibility of measures over time and between locations; and
- sensitivity, or the ability to respond to small changes in measures (16).

Some of the applicable European measures of effectiveness examples are listed below in Table 3-4.

Table 3-4: European MOEs

Goal Area	Measures of Effectiveness
Transportation network and costs	▪ Network utilization ▪ Change in network investment ▪ Change in average speed ▪ Number of incidents ▪ Lost time
Accessibility	▪ Number of visitors to an attraction ▪ Average trip length ▪ Ease of travel ▪ Disabled passengers
Time and predictability	▪ Travel time ▪ Waiting time (terminal stop, intersections) ▪ Transit's deviation from time table
Safety	▪ Number of fatalities ▪ Number of injuries ▪ Number of total accidents ▪ Vehicle miles traveled ▪ Headway distances
Valuation and comfort	▪ Number of users ▪ Opinion of system and characteristics ▪ Willingness to pay for services ▪ Attitudes toward system ▪ Travel comfort
Environmental impacts	▪ Number of inhabitants affected by noise ▪ Number of inhabitants affected by emissions ▪ Air quality indicators ▪ Damage to natural sites ▪ Geographic range of traffic noise ▪ Number of hazardous materials moved

Source: (19)

There was also a special focus on estimating potential benefits from pre-evaluation studies that utilized computer models and simulation. These methods proved to be an effective tool for developing practical, useful MOEs in the early planning stages. Also, there has been interest in developing a single European approach to evaluation, including common European guidelines for ITS evaluation, a common approach to reporting results, a library of reports and a common database for information sharing (16). However, no such common approach has been developed to date.

In the United Kingdom there is a performance-based system-wide approach (similar to the goal-oriented method used in the United States) that correlates value for money to evaluate several different ITS projects. However, there is still a limited understanding and documentation of the quantified benefits.

The investigation of international evaluation methods and the assessment of benefits show they are intrinsically tied to the investment of ITS, whether it is a decision to invest in ITS infrastructure, deploy an ITS-based system, or evaluate the performance of an ongoing ITS-based operation.

4. NATIONAL PARKS

The variety in measures of effectiveness for ITS can be attributed to the variety in applications of ITS. In the United States, ITS deployments and their corresponding evaluations are different than those used internationally, and they even differ within the U.S. between urban and rural settings. The implementation of ITS in a national park setting introduces a new element. The diverse geographical locations of the National Park System, as well as specific, unique traits that characterize individual park units and their associated goals and objectives, indicate the need for special considerations when evaluating ITS applications in these parks. The measures of effectiveness used in national parks may be a combination of existing MOEs, slight variations of existing MOEs, or new MOEs. This chapter will provide an overview of the National Park System and its unique transportation challenges to begin to understand how ITS and their associated evaluations will fit into this specialized system.

4.1. National Park Overview

The National Park Service (NPS) was developed in 1918 with a mission to "preserve the precious lands in their care and to provide the enjoyment of those lands in a manner that will leave them unimpaired for future generations" (20). Planning and developing sustainable, environmentally sensitive roads and transportation systems is central to fulfilling that mission and has been important since the park service's inception. The director of the NPS in 1918 stated, "In the construction of roads, trails, buildings and other improvements, particular attention must be devoted always to the harmonizing of these improvements with the landscape" (21).

The National Park System encompasses 83.6 million acres and is divided into national park units spread over a variety of geographical locations. The park units can be further classified into seven categories. The classifications are shown below in Table 4-1.

These categories may also be classified further based on park-specific characteristics including size, location, or operating time frame. Each category has specific needs with respect to their transportation challenges and corresponding needs for alternative solutions.

Table 4-1: National Park Classifications

Park Unit	Definitions
National Park	These are generally large natural places having a wide variety of attributes, at times including significant historical assets. Hunting, mining and consumptive activities are not authorized.
National Preserve	National preserves are areas having characteristics associated with national parks, but in which Congress has permitted continued public hunting, trapping, oil/gas exploration and extraction. Many existing national preserves, without sport hunting, would qualify for national monuments.
National Monument	The Antiquities Act of 1906 authorized the President to declare by public proclamation landmarks, structures, and other objects of historic or scientific interest situated on lands owned or controlled by the government to be national monuments.
National Historical Park	This designation generally applies to historic parks that extend beyond single properties or buildings.
National Historic Site	Usually a national historic site contains a single historical feature that was directly associated with its subject. Derived from the Historic Sites Act of 1935, a number of historic sites were established by secretaries of the Interior, but most have been authorized by acts of Congress.
National Recreation Area	Twelve NRA's in the system are centered on large reservoirs and emphasize water-based recreation. Five other NRA's are located near major population centers. Such urban parks combine scarce open spaces with the preservation of significant historic resources and important natural areas in location that can provide outdoor recreation for large numbers of people.
National Seashore	Ten national seashores have been established on the Atlantic, Gulf and Pacific coasts; some are developed and some relatively primitive. Hunting is allowed at many of these sites.

Source: (22)

Currently, one of the primary goals of the park system is to find sustainable transportation alternatives that preserve natural resources, while meeting the needs of interested stakeholders and surrounding gateway communities. The diversity of stakeholder groups interested in national parks (e.g. resource protection managers, interpretation staff, local businesses, park partners, concessionaires, chambers of commerce, emergency response) also poses a unique challenge in goal development and the selection of performance measures. There are numerous stakeholders who have interests in the outcome and success of the ITS programs and corresponding positive effects on the transportation problems within parks. Stakeholders at a national level are interested in the broad applicability and transferability, whereas those at the local level are primarily concerned with the more immediate, localized impacts. Finding solutions and measures that satisfy everyone can be difficult. National parks also have significant impacts on the economies, cultural identity and quality of life in the surrounding communities. Transportation improvements should therefore be a coordinated, comprehensive effort to incorporate the needs of the park as well as the surrounding areas.

4.2. Transportation Challenges within National Parks

The most common transportation challenges in a national park setting are related to access, circulation and parking. Limited or impaired ability of visitors to gain access to the park because of congestion restricts visitor mobility, degrades the visitor's park experience and adversely impacts park resources through air and noise pollution. Additional challenges include limited opportunities for visitors to utilize bicycle and hiking trails and insufficient or poorly managed vehicle parking. Some specific objectives related to these challenges include:

- manage transportation demand;
- reduce traffic congestion;
- reduce vehicular travel;
- minimize adverse effects of vehicular traffic on sensitive park resources;
- improve visitor access to park features;
- improve and expand bike and pedestrian access to trails;
- reduce vehicular travel and congestion on trails, roads, and at attractions; and
- eliminate parking lot overflow and related resource degradation (21).

Similar to existing situations outside of national parks, National Park Service facilities and infrastructure are under budgetary and land constraints due to the increasing demand to visit and experience park resources. ITS may be an environmentally and economically viable solution to meeting this increased demand (21). Technologies on their own are not enough, but when they are combined with management strategies, they can help to save lives, time and money. Some particular benefits of ITS applications in national parks can be seen in travel demand and transportation management, pre-trip and en-route traveler information, travel services information, traffic control, public transportation management, electronic payment services, and incident management (23).

There are many potential benefits of ITS; the challenge lies in being able to quantify these benefits with data to support the efforts. The broad applicability of ITS projects suggests that there are many different approaches to evaluate their success. Measures of effectiveness have been developed in rural, urban and international settings. National parks may or may not fall into many of these categories. Examining the unique characteristics of national parks and the possible ITS deployments can provide a better understanding about the transferability of these MOEs.

National parks are relatively new at deploying ITS, but ITS may be important to the future of the National Park Service and its internal goals related to the conservation of natural resources. Several pilot study programs have been implemented throughout the United States to investigate the possible benefits of ITS applications in national parks. Some general measures for evaluating alternative transportation solutions that may be applied to the evaluation of ITS at national parks are included in Table 4-2.

Table 4-2: Possible MOEs for ITS in National Parks

Goals	MOEs
Mobility improvements	▪ Travel time savings ▪ Ability to reduce congestion ▪ Ability to improve access to key locations
Cost effectiveness	▪ Capital expenditures compared to mobility improvements
Operating efficiency	▪ Operating costs compared to mobility improvements
Environmental and cultural benefits and impacts	▪ Effects on critical environmental and cultural resources
Financial feasibility	▪ Ability to construct, operate, and maintain the alternative with existing budgetary constraints
Consistency with existing plans and programs	▪ Conformance to the existing general management plan (GMP), regional land use and transportation policies, and agency mission statements
Public acceptability	▪ Community outreach

Source: (21)

4.3. Examples of ITS Deployments in National Parks

A presidential memorandum issued in 1996 required the Secretary of the Department of Interior and the Secretary of the Department of Transportation to develop a plan to implement alternative transportation solutions in the National Parks; the result was a Memorandum of Understanding (MOU) between the two agencies in 1997. The MOU broadened the involvement of the DOT in park service transportation issues and had a number of different goals including: developing innovative transportation plans, establishing information sharing systems and interagency project agreements, and developing innovative transportation planning tools and policies for the implementation of safe and efficient transportation systems that are compatible with the protection and preservation of the NPS's cultural and natural resources. This MOU increased NPS access to the federal-aid divisions, to the ITS program and to FHWA environmental and planning staff. The implementation action plan was finalized in 1998 (23).

As a result of this agreement, ITS field operational tests were designated to showcase ITS technologies in a national park setting. Three parks were selected to develop strategies and solutions to existing transportation challenges by utilizing ITS. These parks were Acadia, Grand Canyon, and Zion National Park. All three of these parks' deployments focused on traveler information aspects related to their developing transit systems (23).

Acadia National Park is located primarily on Mount Desert Island on the coast of Maine. The park receives over 2.5 million visitors annually with peak visitation months between July and September. The majority of visitors are day users. Acadia National Park has been the leader of the three parks in demonstrating ITS in a national park. From the stakeholders' point of view, the goals of ITS are to reduce vehicle congestion and improve the general visitor experience within the park. The reduced congestion has impacts on numerous other goal areas, through mobility, environment and safety benefits. All of these factors will ideally contribute to a positive visitor experience. The overall system is comprised of nine interrelated components that represent three general areas: traffic management, public transportation and emergency management. The ITS components within Acadia include transit, automatic vehicle location on transit, traveler information, park entrance traffic volume recorder, and parking lot monitoring. The goal areas for the potential benefits are similar in nature to the common goals in urban, rural and international settings, but the specialized characteristics of national parks required adaptations to these common MOEs. Currently, Acadia is the only park that has specific MOEs developed for field evaluation because they are in the evaluation stage, whereas Zion and Grand Canyon are still in the deployment stage. The specific measures and surrogate measures developed for Acadia's ITS deployment are included in Table 4-3.

Table 4-3: Acadia National Park MOEs

Goal Area	MOE	Surrogate Measures
Customer Satisfaction	Awareness and use	▪ How customer became aware of Acadia traveler information services ▪ Expectations of product benefits ▪ Ability to find needed information ▪ Ease of use ▪ Number and type of services used ▪ Occasion of use
	Effect on traveler behavior	▪ Mode choice ▪ Change in destination or time or travel
	Realization of benefits	▪ Ability to visit desired destinations ▪ Fulfillment/unmet needs
	Assessment of value	▪ Enhancement of visitor experience ▪ Value to trip-planning ▪ Park pass sales ▪ Comparison to last visit
	Effect on interagency relationships	
Mobility	Types of users of transit	▪ Characteristics of transit users ▪ Purpose of use of transit
	Ability to reach destination	▪ Destinations of transit users vs. non-transit ▪ Activities of transit users vs. non-transit
	Ability to use transit	▪ Proximity of stop ▪ Service refusals
	Volume of travelers accommodated	▪ Number of vehicles by type ▪ Number of car-less visitors
	Congestion of roadways	▪ Perceived congestion
Energy and Environment	Reduction in emissions	▪ Air quality non-attainment days ▪ Number of bicycles carried on transit ▪ CO, NOx and HC levels ▪ Vehicle counts
	Enhanced natural aesthetics and values	▪ Pounds of trash collected ▪ Number of illegally parked cars ▪ Understanding of national parks mission
	Reduction in fuel consumption	▪ Fuel use: total and per vehicle ▪ Vehicle counts

Table 4-3: Acadia National Park MOEs (cont.)

Goal Area	MOE	Surrogate Measures
Productivity	Operational improvements	▪ Transit staff overtime ▪ Transit cost per passenger ▪ Missed runs ▪ On-time performance ▪ Missed connections ▪ Operations and maintenance costs
	Economic benefit	▪ Visitor expenditures ▪ Duration of visitor stay ▪ Sales tax receipts ▪ Donations collected ▪ Park entrance fees collected
Safety	Improved emergency response	▪ Roadway ▪ Back country ▪ Reporting time for emergencies/incidents
	Reduced incidents	▪ Incidents by location ▪ Incidents by mode
	Reduction in hazardous conditions	▪ Number of illegally parked cars ▪ Crush loads on buses
Efficiency	Increase in throughput	▪ Efficient incident management ▪ Efficient planning ▪ Crush loads on buses ▪ Number of stops at visitor centers ▪ Dispatcher efficiency
	Increase in capacity	▪ Decrease parking lot closures ▪ Standing riders ▪ Denied riders ▪ Overall car count ▪ Number of illegally parked cars
	Quality of visitor experience	▪ Arrival/departure times ▪ Analysis of web usage ▪ Reduction in stops at visitor center for information

Source: (24)

Grand Canyon National Park is located in the northeastern corner of Arizona, covering in excess of 1.2 million acres. Annual visitation is estimated at 5 million visitors and peaks during the summer months. Grand Canyon National Park is in the process of developing and implementing transportation improvement initiatives, including evaluating the feasibility of a light rail and alternative bus transportation system, participating in the effort to develop a regional transportation system, and researching ITS technological applications for use in the park, such as electronic collection of entrance fees (23).

Zion National Park is located in the southwest corner of Utah. Its proximity to many other national parks, including Grand Canyon, offers some additional potential benefits of an integrated ITS system. Currently, Zion is in the process of developing and implementing major, innovative transportation improvement initiatives, including the use of a transit system. This pilot project relies heavily on the cooperation of adjacent communities for the successful system integration within the park and the surrounding, gateway communities. ITS technologies will assist in distributing transit-related information to approaching visitors before they arrive at the park.

Many of the measures of effectiveness to evaluate these components require the collection of data over a long period of time. The presence of ITS systems is relatively new in the realm of national parks, and it will be difficult to analyze and measure the benefits for many of the goal areas until an adequate amount of baseline data, as well as yearly comparative data, is collected and stored.

In addition to these three demonstration parks, other national parks have ITS deployments in place. Great Smoky Mountains National Park lies along the border of Tennessee and North Carolina. The park has just over half a million acres and is open year-round. The annual visitation is estimated at more than 10 million. Three main access points include Cades Cove, Tennessee; Gatlinburg, Tennessee; and Cherokee, North Carolina. Each entrance point receives between two and three million visitors per year, with the peak season in the fall. The large geographical area, seven gateway communities, multi-jurisdictional entities, different interest groups, and a lack of advanced communication infrastructure pose many transportation challenges. Proposed solutions involving coordination and demonstration efforts for ITS technologies may provide significant benefits. Some of these technologies include fleet management software, automatic vehicle location, multi-media display within vehicles, and automatic passenger counters. Possible performance measures related to these technologies include enhanced visitor experience, improved emergency response, expected arrival/departure times, and transit usage and benefits through reduced congestion and improved air quality (25).

Yosemite National Park is located in the Sierra Nevada Mountains in California. The park encompasses 700,000 acres of mountains and valleys. The Yosemite Area Regional Transportation Strategy (YARTS) was formed in 1992 to explore alternatives that would provide continued access to the park while reducing the negative impacts of auto traffic. The Yosemite Area Traveler Information System (YATI) has been in operation since 1995 and includes five changeable message signs (CMS), five highway advisory radio (HAR) stations, Internet-based kiosks and a web site. CMS and HAR provide information related to road and weather conditions, parking expectations, emergency conditions and alternatives at entry points. The kiosks provide traveler information to visitors in and approaching the park. The web site provides information on lodging, dining, services, and special events. A field operational test is being conducted on the operational system to determine the benefits of real-time traveler information systems in rural tourist areas (26). The evaluation of this program is based on automobile visitor baseline data collection, web site users, focus groups, kiosk users, CMS and HAR user tests, institutional interviews, and YARTS data collection. Measures of effectiveness include the use of the ITS technologies, high quality experience for visitors, air quality and resource protection with a focus on critical natural resource areas that are fragile, rare or critical in maintaining biological diversity (23).

Yellowstone National Park is a rural national park located on the border of Montana and Wyoming. This park covers more than 2.2 million acres and receives more than 3 million visitors per year. Yellowstone is accessible from each side of the park, although some entrances and roads may be closed due to inclement weather conditions. Similar to many other national parks, Yellowstone has deployed ITS as a solution to increasing transportation challenges. An evaluation plan was developed for the various ITS technologies in place including automatic vehicle identification, touch screen kiosks, and dynamic warning variable message signs. The measures of effectiveness by project are listed in Table 4-4.

Table 4-4: Yellowstone National Park MOEs

ITS Deployment	MOE
Automatic Vehicle Identification	▪ Total measured time of delay due to entrance gates ▪ Total estimated time of delay due to entrance gates (what is the difference?) ▪ Change in park's staffing needs ▪ Park personnel hours spent maintaining the system ▪ User acceptance
Dynamic Warning Variable Message Signs	▪ Number of accidents related to the identified hazard ▪ Changes in speed ▪ Driver reported reaction to sign ▪ Number of false correlations between sign value and measured values ▪ Driver reported awareness of hazardous condition
Touch Screen Kiosks	▪ Change in traveler's knowledge of goods, services, and opportunities in regional communities ▪ Change in traveler's knowledge of construction and weather conditions ▪ Traveler reported change in travel ▪ Change in usage of transportation alternatives ▪ Change in traveler's knowledge of transportation alternatives ▪ Number of users

Source (27)

These case studies illustrate some current ITS deployments in national parks and the potential benefits that may result. Overlap between ITS themes and the benefits among different national parks, combined with a continued emphasis on the importance of evaluation strategies, contributes to the need for a unified evaluation strategy for national parks. Shared information and a comprehensive outline of anticipated benefits can assist in the planning and implementation of future ITS efforts in other national parks.

5. GOALS AND OBJECTIVES OF ITS IN NATIONAL PARKS

Transportation professionals evaluate ITS to understand its impacts, quantify its benefits, help make future investment decisions and optimize the existing system with respect to operation and design. Evaluation is used to determine how well project goals and objectives are being achieved. The primary purpose of evaluation is to gather information that can help to make decisions regarding the project so that it eventually meets or exceeds the stated goals and objectives. The field operational tests and model deployments described in previous chapters have been used to evaluate the success of ITS on a case study basis, in rural and urban areas respectively. Evaluation strategies for ITS deployments in national parks will incorporate designated measures of effectiveness that look at the specific goals and objectives.

The underlying mission that is rooted in the development of national parks greatly affects how the goals are set up and the specific areas of focus. A good example is the National Park Service's objective of upholding and enhancing visitor experience. A primary goal of an urban freeway is typically not to enhance the driver's experience, although that might happen as a corollary of another action. Also, although the objective may be the same, the management approach may be significantly different. The objective to manage congestion obviously has different applications in various settings; the key is determining and outlining the necessary adjustments and guidelines that should be included as part of the MOE designation that will most accurately evaluate the specific goal. The purpose of this study is to provide an understanding of unique aspects of ITS goals and objectives in a national park setting, in order to guide management in the selection of appropriate and useful MOEs.

Goals and objectives related to ITS applications were developed in Phase 1 of the California National Parks ITS Needs Assessment (28). These goals were developed to provide consistency between urban and rural areas, although there is some variance based on the particular area. Some additional goals and objectives have been added to encompass the broad range of needs in national parks.

Table 5-1 shown below includes the areas of focus for this study.

Table 5-1: ITS Goals and Objectives

Goal 1: Enhance the visitor experience

Objective 1.1: Provide real-time, accurate, convenient and relevant information to visitors to help them make travel decisions

- Objective 1.1.1: Develop predictive information that will help visitors plan their trips better
- Objective 1.1.2: Provide appropriate information at major transportation decision points
- Objective 1.1.3: Provide information to help visitors avoid congested locations and times
- Objective 1.1.4: Provide weather, road condition, and chain requirement information
- Objective 1.1.5: Provide construction and work zone information
- Objective 1.1.6: Provide information on parking availability
- Objective 1.1.7: Provide information at various park sites about transit arrivals and schedules
- Objective 1.1.8: Provide air quality information

Objective 1.2: Improve visitor safety

- Objective 1.2.1: Improve the safety of vehicles at or approaching congested entrance stations
- Objective 1.2.2: Improve the safety of vehicle travel on park roadways
- Objective 1.2.3: Improve the safety of vehicle travel through work zones in the park
- Objective 1.2.4: Improve the safety of bicyclists and pedestrians approaching popular destinations

Objective 1.3: Enhance visitor access to the variety of natural, cultural, recreational and educational opportunities available at the park and surrounding areas

- Objective 1.3.1: Improve access options for visitors without automobile access
- Objective 1.3.2: Provide transit service that enables visitors to see attractions that may not have been possible because of unavailability of parking

Objective 1.4: Improve visitor convenience

- Objective 1.4.1: Reduce the delay to visitors waiting in long lines at entrance stations
- Objective 1.4.2: Decrease the difficulty in finding available campsites
- Objective 1.4.3: Allow visitors to make reservations for experiencing certain park activities
- Objective 1.4.4: Provide customized and enhanced interpretation through in-vehicle or handheld systems

Goal 2: Assist in resource protection

Objective 2.1: Encourage use of alternative modes of transportation to, from or within the park

- Objective 2.1.1: Increase usage of transit, pedestrian and bicycle modes for park access
- Objective 2.1.2: Increase usage of alternative transportation systems within park
- Objective 2.1.3: Promote information about non-automobile alternatives

Objective 2.2: Monitor and reduce vehicle emissions

- Objective 2.2.1: Reduce emissions of idling vehicles in parking areas
- Objective 2.2.2: Reduce emissions of idling vehicles at entrance gates
- Objective 2.2.3: Improve the monitoring of air quality in the park
- Objective 2.2.4: Improve water quality
- Objective 2.2.5: Reduce amount and location of polluted runoff

Objective 2.3: Protect the road infrastructure as a park resource

- Objective 2.3.1: Re-direct oversize vehicle traffic to reduce roadway impacts
- Objective 2.3.2: Reduce time required for snow removal and other roadway maintenance

Table 5-1: ITS Goals and Objectives (cont.)

Goal 3: Improve management of the park's transportation system

- Objective 3.1: Manage congestion within the park
  - Objective 3.1.1: Predict occurrence and duration of congestion based on historical and real-time information
  - Objective 3.1.2: Monitor transportation operations and congested areas
  - Objective 3.1.3: Reduce congestion on park roadways
- Objective 3.2: Manage incidents to reduce their impact on the park's transportation system and promote visitor safety
  - Objective 3.2.1: Improve the response time to incidents along park roadways
  - Objective 3.2.2: Provide for prompt and efficient evacuation of visitors during major emergencies
- Objective 3.3: Manage construction and work zone activities and special events to minimize visitor inconvenience
  - Objective 3.3.1: Enhance interagency coordination and communication regarding work zones and special events
  - Objective 3.3.2: Reduce the vehicle delay through work zones within the park
  - Objective 3.3.3: Use archived data to help to promote improved planning for the impacts of special events on the local transportation system
- Objective 3.4: Manage parking facilities within the park
  - Objective 3.4.1: Reduce congestion in and around parking areas
  - Objective 3.4.2: Reduce parking outside of designated parking areas
  - Objective 3.4.3: Improve management of existing parking facilities to optimize parking usage
- Objective 3.5: Manage transit systems providing access to park sites
  - Objective 3.5.1: Improve efficiency and level of service of transit operations within the park
  - Objective 3.5.2: Enhance the monitoring and coordination of various transit operations serving the park
- Objective 3.6: Manage data to promote better transportation planning in the park
  - Objective 3.6.1: Enhance the reliability, accuracy, and timeliness of visitation statistics
  - Objective 3.6.2: Collect additional statistics to help in transportation planning (e.g. distinguish between travelers and visitors, determine linked trips and trip patterns, count non-motorized travel)
- Objective 3.7: Manage the transportation impact of the park's visitation on surrounding communities
  - Objective 3.7.1: Manage adverse traffic impacts on local communities while preserving the economic benefits of tourist activity
  - Objective 3.7.2: Promote sharing of information regarding tourist activities between the park and local communities

5.1. Enhanced Visitor Experience

Visitor experience is an essential element to the success of national parks and their surrounding gateway communities. Customer satisfaction is therefore a critical objective; however, linking quantifiable benefits to this goal may be difficult due to the qualitative nature of the benefits. National parks were developed for the visitors, so that future generations could continue to enjoy these magnificent, protected areas. In addition, gateway communities rely on tourists as the primary source of income and economic stability.

Peak visitor seasons, typically summer for most national parks, make up a large portion of total, yearly revenues. Parks and the gateway communities are highly dependent on these revenues to carry them through the off-peak season. From this perspective, the high volumes of people are beneficial; unfortunately, the same benefit is not seen in the corresponding high volumes of vehicles. High traffic volumes, if not effectively managed, can significantly degrade the quality of the visitor's experience.

A visitor's experience is based upon many different factors and spans a long time frame: planning the trip, en-route to destination, at the destination and leaving the destination. ITS applications that provide accurate real-time information to visitors can assist travelers throughout the trip process. Evaluation areas include questions such as: did visitors use ITS, did it change their travel behavior, and did the travel behavior result in a reduction in congestion. It is a multi-tiered question that evaluates the individual travel behavior as well as the effect on the system as a whole.

In a national park setting, there are often limited alternate routes. It is necessary that a visitor knows well in advance of a decision point about a particular inhibiting traffic concern, construction or weather condition. This is in contrast to many urban areas, where there are more access points so drivers would not have to travel very far to change their route. To obtain real-time information, park visitors may be more likely to use informational kiosks and other highway information systems and rely more heavily on these alternate sources, because they are in an unfamiliar area.

The concept of alternative transportation is important to the national parks' ability to sustain future demand without harming resources. The use of transit in a national park setting is different than its use in an urban setting, specifically with respect to the leisure versus necessity nature of the trip. On-time arrivals may not be as critical for park visitors, whereas how well the transit fits aesthetically into the national park environment may be a higher priority. Another important purpose of transit is to provide access for those who do not have any other means to enjoy all that national parks have to offer. This coincides with the goal of a national park providing a recreation area that everyone can enjoy, even those without private automobiles. The operations and management aspects of ITS in relation to providing information to visitors are similar to those in urban settings, and may involve coordination between two adjacent areas and surrounding gateway communities.

5.2. Assist in Resource Protection

Environmental concerns are a consideration for all transportation projects, and with good reason. Vehicles on the roadway contribute to air pollution via carbon monoxide and other gaseous emissions which are extremely harmful to the environment, and through highway runoff into streams and watersheds. Pollution is a pressing concern in urban areas all over the world and national parks are not immune to these problems. Increased traffic volumes traveling through the park are not the only sources of emissions; idling at entrance gates and parking lots also contribute significantly. The difference, however, is based on the foundation of the national park concept. In the mission statement, one of the most critical goals is resource protection. These special lands were set aside so that specific features could be preserved for future generations to enjoy. Therefore, the focus on maintaining these lands is one of the highest priorities.

Efficient use of the transportation system through encouraging alternative modes of transportation (e.g. transit and improved bicycling and walking paths) is another important objective of maintaining the national park system. Similar to urban settings throughout the U.S., encouraging the use of transit can be a difficult task. ITS applications aid in that process, specifically with respect to the development of usable transit systems.

National parks have special restrictions with respect to the amount of infrastructure improvements that can be made within the park due to the negative implications on traffic flow and the associated environmental concerns. Heavy vehicle monitoring and regulations, including rerouting oversize vehicles from the main roadway and minimizing the time to remove snow and perform maintenance operations, are important objectives to maintaining the existing infrastructure. To accomplish these tasks, ITS applications are particularly important and the effective MOEs differ from those of typical transportation systems in rural and urban areas.

5.3. Improving Management of the Park’s Transportation System

The management of a national park involves many different components which, due to the unique characteristics of travel patterns and infrastructure in national parks, are different than typical urban and rural areas. Peak hour volumes are typically seen all day, over a specific season, instead of peak hours in the morning and afternoon for commuters. Also, while the underlying purpose of a roadway in most areas is moving as many cars as possible, this type of mobility is not usually the primary goal in a national park setting, and the definition of acceptable congestion may be different. Additionally, a transportation system operating within park boundaries may extend to include the surrounding gateway communities. This coordinated effort offers many benefits, but increases the level and scope of management required.

National park roads are used primarily for recreational trips. Visitors do not want to rush by the scenery; therefore, slower speeds and narrow, winding roadways accommodate that specific characteristic. Recreational vehicles’ presence in the traffic flow also contributes to slower speeds. Additionally, infrastructure expansion is significantly more limited within national parks as compared to urban and rural areas throughout the country. The specific, strict regulations restricting capacity enhancements that characterize national parks make the task of reducing congestion through alternate means more challenging.

Congestion in national parks has many different sources, in addition to peak visitor travel. Incidents are a significant contributor to congestion in both rural and urban areas. Similar to many rural areas, the travel distance from a national park to the nearest medical services can be considerable and time is a critical element. Infrastructure limitations, such as narrow travel lanes and minimal or no shoulders, can contribute to incident response challenges within the parks. Another contribution to congestion is the presence of work zones and the associated delays. Limited numbers of alternate routes through a national park pose particular challenges. Work zone related delays can be minimized through traveler’s knowledge of construction activities, but this is heavily dependent on accurate real-time information. Additionally the distances between scenic destinations, and thus the next parking lot, are often significant in national parks. Travelers who reach the destination without knowledge of the status of a particular parking lot spend extra time driving around looking for a spot, thereby exacerbating the congestion problem.

Because of different management goals and operational requirements, national parks also follow different standards and guidelines with respect to data collection requirements. The data needed to support many of the MOEs that are being discussed are different than what currently have been collected. A continued focus on collecting and organizing the data for future use should be exercised. New needs put an additional emphasis on the data collection efforts and the importance of the reliability, accuracy and timeliness of the various statistics.

Clearly stated goals contribute to the selection of MOEs that can accommodate the expectations and needs of the stakeholders. In addition to the hierarchy of interested parties, the goals of park management may differ from the expectations of the visitor. ITS applications and their corresponding evaluations need to coincide with the general management plan that outlines the primary mission and basis of the development and sustainability of the national parks. Often, the evaluation results may be successful from management's perspective, but less than adequate from a visitor's perspective. Finding an appropriate balance between these two viewpoints, with respect to established goals and objectives, may be achieved by examining the different needs and providing specific guidelines to the selected MOEs.

6. DEVELOPING MOES FOR NATIONAL PARKS

There are many different ITS deployments that may be used in national parks, ranging from individual components to more complex, integrated systems. Goals and objectives related to the three primary areas of focus for ITS deployments in national parks – visitor enhancement, resource protection and improved management of the park's transportation system – were discussed in the previous chapter. The distinguishing characteristics between national parks and other urban and rural areas reflect the economic impacts on the corresponding gateway communities and the reliance on customer satisfaction for return trips. Additionally, environmental goals are of particular importance and contribute to the ultimate mission of resource protection.

Developing MOEs that are applicable to a wide range of projects is very beneficial from an economical standpoint. Providing a similar set of guidelines (i.e. few good measures) that can be used for national parks is an important tool for the evaluation of ITS deployments in national parks. Ultimately, the goal is cost-effective measures that can be used for many different applications, as well as an outline of additional considerations that are based on the unique characteristics of the park and the corresponding ITS deployment.

The "few good measures" that have been established at a national level include safety, mobility, capacity/throughput, customer satisfaction, productivity and the environment. This breakdown provides categories that are broad enough to represent the goals and objectives on a system-wide basis, but are few enough to be affordable for tracking on a yearly basis. These national measures, as they are, do not address all of the challenges and needs of park managers and visitors in national parks. The goals and objectives of a transportation system within a national park differ from those in an urban setting for which the original measures were specifically designed. The MOEs for national parks need to reflect that difference to appropriately accommodate the needs of an evaluation plan specifically for national parks.

As discussed previously, the few good measures developed by the ITS Joint Program Office were used as a starting point to create the rural MOEs, although they were modified to meet the specific needs of rural settings. The alterations to the corresponding MOEs were based on specific, unique characteristics of rural areas. Similarly, national parks are a new area of ITS deployment that requires additional considerations. The NPS mission along with parks' individual general management plans contribute to the specialized goals that are required for the appropriate development of effective MOEs. Therefore, in this research project, the national MOEs will be used as a starting point for creating the national parks' MOEs.

Of the six national measures, two of them are not applicable in a national park setting: capacity/throughput and productivity. Although it is important to serve the growing traveler demands, the actual capacity of a roadway in a national park exceeds the social perceptions of capacity. Measurements that evaluate maximum throughput on the roadway contradict the essential goals and recreational aspects of a national park. Access, on the other hand, is an important factor that is not typically as important in an urban setting based on the nature of urban development patterns that favor more frequent access points. In rural areas though, the importance of access for normal travel and also emergency vehicle access is increased. The evaluation plans for the rural FOTs on Interstate 40 in Arizona and in Branson, Missouri introduced the concept of access as an important goal area. These areas, as discussed previously, are primarily focused on rural tourism; therefore, the idea has strong applicability in national parks. National parks have numerous attractions, but often there are limited routes to visit these attractions. Routes throughout the park may be limited to constrain the amount of roadway infrastructure, and thus disturbance of natural resources, to a minimum. Also, alternate routes are not always available due to incidents or work zones. If they are, the decision point is often a long distance from the actual incident and advance notification is essential.

Productivity is another area that is a priority measure at the national level, but in a park setting does not yield the same benefits. Productivity measures related to data collection and sharing between agencies are important and represent the need for standardized guidelines for data collection and storage, whereas productivity in relationship to park staff managing more visitors is not necessarily a positive benefit. Serving as many visitors as possible with minimal personal staff contact is not appropriate in a national park, primarily because of the recreational aspect of travel within the park, and actually may be seen as more of a negative impact of technology. A more appropriate category is efficiency, which looks at the best way to manage the given demand. Efficiency measures how well the system is operating, based on the level of effort and expense that is being put into it. From a park management perspective, efficient use of the existing infrastructure and resources is essential and can be achieved through interagency coordination and ITS technologies.

After a project is selected, the goals and objectives are determined by stakeholders. For this particular study, the goals and objectives of NPS were introduced in the previous section. Next, these goals and objectives must be matched to the resulting six evaluation goal areas. This relationship is shown below in Table 6-1. The six evaluation goal areas discussed in this section are modeled after the JPO's national six goal areas. This table demonstrates how the evaluation goal areas tie into the NPS mission and goals and highlights the importance of the modified goal areas, efficiency/economics and access. The correlation between these two areas is an important step to develop the foundation of the comprehensive list of MOEs that will follow.

Table 6-1: Relationship between NPS Goals and Objectives and Evaluation Goal Areas

National Park Goals and Objectives		Evaluation Goal Area
Goal 1:	**Enhance the visitor experience**	
Objective 1.1:	Provide real-time, accurate, convenient and relevant information to visitors to help them make travel decisions	Mobility
Objective 1.1.1:	Develop predictive information that will help visitors plan their trips better	Customer satisfaction
Objective 1.1.2:	Provide appropriate information at major transportation decision points	Mobility
Objective 1.1.3:	Provide information to help visitors avoid congested locations and times	Mobility
Objective 1.1.4:	Provide weather, road condition, and chain requirement information	Mobility
Objective 1.1.5:	Provide construction and work zone information	Customer satisfaction
Objective 1.1.6:	Provide information on parking availability	Customer satisfaction
Objective 1.1.7:	Provide information at various park sites about transit arrivals and schedules	Customer satisfaction
Objective 1.1.8:	Provide air quality information	Customer satisfaction
Objective 1.2:	Improve visitor safety	Safety
Objective 1.2.1:	Improve the safety of vehicles at or approaching congested entrance stations	Safety
Objective 1.2.2:	Improve the safety of vehicle travel on park roadways	Safety
Objective 1.2.3:	Improve the safety of vehicle travel through work zones in the park	Safety
Objective 1.2.4:	Improve the safety of bicyclists and pedestrians approaching popular destinations	Safety
Objective 1.3:	Enhance visitor access to the variety of natural, cultural, recreational and educational opportunities available at the park and surrounding areas	Access
Objective 1.3.1:	Improve access options for visitors without automobile access	Access
Objective 1.3.2:	Provide transit service that enables visitors to see attractions that may not have been possible because of unavailability of parking	Access
Objective 1.4:	Improve visitor convenience	Customer satisfaction
Objective 1.4.1:	Reduce the delay to visitors waiting in long lines at entrance stations	Customer satisfaction
Objective 1.4.2:	Decrease the difficulty in finding available campsites	Customer satisfaction
Objective 1.4.3:	Allow visitors to make reservations for experiencing certain park activities	Customer satisfaction
Objective 1.4.4:	Provide customized and enhanced interpretation through in-vehicle or handheld systems	Customer satisfaction

Table 6-1: Relationship between NPS Goals and Objectives and Evaluation Goal Areas
(cont.)

National Park Goals and Objectives		Evaluation Goal Area
Goal 2:	**Assist in resource protection**	
Objective 2.1:	Encourage use of alternative modes of transportation to, from or within the park	Access
Objective 2.1.1:	Increase usage of transit, pedestrian and bicycle modes for park access	Access
Objective 2.1.2:	Increase usage of alternative transportation systems within park	Access
Objective 2.1.3:	Promote information about non-automobile alternatives	Access
Objective 2.2:	Monitor and reduce vehicle emissions	Environment
Objective 2.2.1:	Reduce emissions of idling vehicles in parking areas	Environment
Objective 2.2.2:	Reduce emissions of idling vehicles at entrance gates	Environment
Objective 2.2.3:	Improve the monitoring of air quality in the park	Environment
Objective 2.2.4:	Improve water quality	Environment
Objective 2.2.5:	Reduce amount and location of polluted runoff	Environment
Objective 2.3:	Protect the road infrastructure as a park resource	Environment
Objective 2.3.1:	Re-direct oversize vehicle traffic to reduce roadway impacts	Environment
Objective 2.3.2:	Reduce time required for snow removal and other roadway maintenance	Environment
Goal 3:	**Improve management of the park's transportation system**	
Objective 3.1:	Manage congestion within the park	Mobility
Objective 3.1.1:	Predict occurrence and duration of congestion based on historical and real-time information	Mobility
Objective 3.1.2:	Monitor transportation operations and congested areas	Mobility
Objective 3.1.3:	Reduce congestion on park roadways	Mobility
Objective 3.2:	Manage incidents to reduce their impact on the park's transportation system and promote visitor safety	Mobility
Objective 3.2.1:	Improve the response time to incidents along park roadways	Mobility
Objective 3.2.2:	Provide for prompt and efficient evacuation of visitors during major emergencies	Safety
Objective 3.3:	Manage construction and work zone activities and special events to minimize visitor inconvenience	Mobility
Objective 3.3.1:	Enhance interagency coordination and communication regarding work zones and special events	Mobility
Objective 3.3.2:	Reduce the vehicle delay through work zones within the park	Mobility
Objective 3.3.3:	Use archived data to help to promote improved planning for the impacts of special events on the local transportation system	Efficiency
Objective 3.4:	Manage parking facilities within the park	Access
Objective 3.4.1:	Reduce congestion in and around parking areas	Mobility
Objective 3.4.2:	Reduce parking outside of designated parking areas	Mobility
Objective 3.4.3:	Improve management of existing parking facilities to optimize parking usage	Access

Table 6-1: Relationship between NPS Goals and Objectives and Evaluation Goal Areas (cont.)

National Park Goals and Objectives		Evaluation Goal Area
Goal 3:	**Improve management of the park's transportation system (cont.)**	
Objective 3.5:	Manage transit systems providing access to park sites	Access
Objective 3.5.1:	Improve efficiency and level of service of transit operations within the park	Efficiency/Economics
Objective 3.5.2:	Enhance the monitoring and coordination of various transit operations serving the park	Efficiency/Economics
Objective 3.6:	Manage data to promote better transportation planning in the park	Efficiency/Economics
Objective 3.6.1:	Enhance the reliability, accuracy, and timeliness of visitation statistics	Efficiency/Economics
Objective 3.6.2:	Collect additional statistics to help in transportation planning (e.g. distinguish between travelers and visitors, determine linked trips and trip patterns, count non-motorized vehicles)	Mobility
Objective 3.7:	Manage the transportation impact of the park's visitation on surrounding communities	Efficiency/Economics
Objective 3.7.1:	Manage adverse traffic impacts on local communities while preserving the economic benefits of tourist activity	Efficiency/Economics
Objective 3.7.2:	Promote sharing of information regarding tourist activities between the park and local communities	Efficiency/Economics

6.1. MOE Goal Areas for National Parks

The large number of possible evaluations contributes to many different categories for MOEs. Due to funding and time limitations, the most effective measures should be selected and used, with a particular emphasis on those that relate closely to the outlined goals and objectives of a specific project. The categories described below are similar to the few good measures developed earlier at a national level. Each of these evaluation goal areas and the corresponding MOEs that have been selected relate strongly to the underlying mission of the National Park Service and as represented in Table 6-1, are tied to the most critical goals and objectives. Additionally, each individual park has a general management plan that represents their individual mission and goals. From park management's perspective, adherence to these plans is very important and these categories may be easily altered to encompass the specific needs of the individual plans.

6.1.1. Safety

The desire to utilize ITS to improve safety is a priority in most rural deployments and is equally important in national parks. The safety of visitors, as well as park staff, encompasses many areas, including incidents, natural disasters, as well as the perception of safety. Traveler information systems that have the ability to alter driver behavior to avoid an incident location and other technologies that improve incident detection and response times represent a few ITS deployments that can enhance safety. Accidents also have significant impacts on congestion, mobility and customer satisfaction. This illustrates the idea that these MOE areas are interrelated and that one MOE may affect the evaluation of many different areas.

6.1.2. Mobility

Mobility in a national park has a different connotation than mobility on an urban freeway. The amount of delay that is incurred as a result of congestion relates highly to customer satisfaction in all settings; however, visitor experience during the journey is not typically a significant consideration in non-tourism areas. The type and location of delay, as well as whether it was expected or unexpected, can influence a visitor's reaction to the delay. Delay may be more acceptable within the park because of the recreational aspect of the trip, which may include wildlife viewing and continued stops at attractions, for example. Maintaining adequate mobility and movement, especially through problematic areas such as work zones, entrance gates and other highly congested areas, is essential. It is also important to recognize the perception of congestion from a tourist's perspective and how that differs from an urban or rural setting.

6.1.3. Access

Access is another essential component of the National Park Service's mission, as well as many of the individual general management plans. Tourism areas have limited access points into and within the park. Assuring that access is available to all of the different attractions within the park can be successfully achieved through ITS real-time travel information, pre-planning tools (such as websites and kiosks), as well as transit alternatives and management of those systems. Early notification of possible congestion and sources of delay can affect driver behavior. Additionally, benefits to emergency vehicles through planning and usage of alternate routes, and quicker response times to incidents, positively impact the safety of travelers. Once again, improved access has other impacts on visitor experience, as well as the probability of return trips and thus economic growth.

6.1.4. Customer Satisfaction

Customer satisfaction is important because of the emphasis on visitor experience to fulfill the NPS mission and also as a key element for encouraging return trips and economic growth. The benefits that can be attributed to customer satisfaction include more return trips, more time spent in the park and surrounding community, and compliance with the general management plan. This category focuses on how well the deployment meets user expectations. User expectations vary from location to location; tracking these expectations and assuring that benefits from changes to the transportation systems are utilized to their full potential is important. Another aspect is the aesthetics of ITS systems (i.e. changeable message signs) and how well they mesh with the surrounding environment. Some essential questions to be answered include: did the customer use the ITS system, did it change their travel behavior, and did that change in travel behavior have a positive impact on congestion reduction. Real-time traveler information systems have a great potential for providing benefits to the user, such as time savings from avoiding congested areas.

6.1.5. Efficiency/Economics

National parks occupy a fixed space of land, and while pushing through the greatest number of visitors in a minimal amount of time is not a primary goal, economics play an important role in the continued vitality of parks and surrounding communities. Economic growth for parks and the surrounding communities is essential to success, specifically from a management point of view. Efficient use of the existing transportation infrastructure prevents the need for future expansion that is not necessarily an option due to the limited room for added capacity. Appropriate management of the components of the transportation system can contribute to maximum efficiency. Visitors have limited understanding of the logistics of the system and are primarily concerned with personal delay. For this reason, park management and related agencies can more accurately measure the efficient operation of a system.

6.1.6. Environment & Resource Protection

Environmental concerns include air quality, fuel consumption considerations, and the protection of the natural resources that are such an important part of national parks. Many of the sites and attractions within the park are extremely fragile and irreplaceable. Damage done to these sites cannot be fixed or replaced, and cultural and historic resources may be lost forever. The presence of wildlife and their migration patterns represent another environmental concern that can be affected by the transportation system. ITS applications that protect these resources, reduce congestion and manage transportation systems within the park yield many important environmental benefits. Visitors typically have a higher expectation of aesthetics and a clean environment in a national park, and thus small changes may influence customer satisfaction at a disproportionate rate. Also, infrastructure expansions have a more significant impact on the environment and the surrounding natural sites within a national park.

6.2. MOEs Related to Primary Goal Areas in National Parks

The sequence of the evaluation process begins with the development of ITS goals and objectives determined by stakeholders. Corresponding MOEs are then developed to assess these goals and objectives. Table 6-2 provides a comprehensive list of MOEs that are categorized by the goal areas discussed in the previous section.

Table 6-2: MOEs for National Parks

Goal Area	MOE	Data Collection Method
Safety	Number of incidents	Park police records (within park) Local law enforcement records (outside park)
	Severity of incidents	Park police records (within park) Local law enforcement records (outside park)
	Locations of incidents	Park police records (within park) Local law enforcement records (outside park)
	Types of incidents (bicycle, pedestrian, vehicle)	Park police records (within park) Local law enforcement records (outside park)
	Increased awareness of potential safety hazards	Visitor survey
	Reduced incident detection/response time	Park police records (within park) Local law enforcement records (outside park)
	Visitor perception of safety	Visitor survey
	Management perception of safety	Management survey
	Improved incident management/evacuation plans	Agency interviews
Mobility	Level of service	Traffic counts Speed studies Visual observation
	Number of delays	Visitor surveys
	Location of delays	Visitor surveys Direct observation
	Improved throughput/processing at entrance gates	Direct observation System data
	Variability in travel time between two specific points	Travel time study
	Park staffs perception of time savings as result of ITS	Management survey
	Visitor perception of congestion	Visitor survey
	Management perception of congestion	Management survey
	Average speeds through congested areas	Speed study
	Average speeds through non-congested areas	Speed study
	Queue length at entrance gates	Visual observation
	Improve transportation system management and planning	Agency interviews
	Increase transit, pedestrian and bike options	Visitor survey Transit usage statistics Bicycle traffic counts
	Free flow speed	Speed study
	Mode split entering park (bicyclists, pedestrian, transit, auto)	Visitor survey Transit usage statistics Bicycle traffic counts Pedestrian traffic counts
	Number of vehicles by type	System data
	Number of car-less visitors	System data
	Change in speed over segment	Speed study

Table 6-2: MOEs for National Parks (cont.)

Goal Area	MOE	Data Collection Method
Access	Knowledge of travel options	Visitor survey
	Knowledge of special event information	Visitor survey
	Ability to visit all desired destinations	Visitor survey
	All attractions known and visited	Visitor survey Park site-use statistics
	Number of attractions visited per visitor	Visitor survey Park site-use statistics
	Number of tourists who changed the attractions they visited because of information obtained through ITS	Visitor survey Park site-use statistics
	Improve access to transit/alternative transportation	Interview/visitor survey
	Improved parking access	Visitor survey
	Reduced snow removal, incident removal, and roadway maintenance times	Park management records Park police records (within park) Management survey/System data
Customer Satisfaction	Number of website/kiosk/traveler information users	System data
	Number of users reported behavior change (time, mode, destination)	Visitor survey
	Number of users that reported knowledge of construction/weather	Visitor survey
	Number of users that reported time savings	Visitor survey
	Public acceptability of ITS deployment	Visitor survey/Interview
	Public's enjoyment of visit	Visitor survey
	Public's stated willingness to return to park	Visitor survey
	Duration of stay in park	Visitor survey Park visitation statistics
	User acceptance (aesthetics)	Visitor survey
	Park pass sales	Park visitation statistics
	Ability to find needed information	Visitor survey
	Expectation of benefits	Visitor survey
Efficiency and Economics	Comparison to last visit	Visitor survey
	Management perception of efficient operation/time savings as a result of ITS implementation	Management survey
	Enhance interagency coordination	Agency interviews
	Increased visitation	Park visitation statistics
	Efficient use of park staff/change in park staff needs	Park management records
	Economic cost related to maintenance and construction	Park visitation statistics Park management records Interview of local businesses Visitor surveys
	Economic cost of incidents and lost time	Park police records (within park) Local law enforcement records (outside park) Park management records Park visitation statistics

Table 6-2: MOEs for National Parks (cont.)

Goal Area	MOE	Data Collection Method
Efficiency and Economics (cont.)	Economic cost of travel from origin and destination	Travel time study
	Economic benefit to gateway communities	Interview of local businesses Visitor surveys Park visitation statistics/modeling
	Overall vehicle count	Traffic counts entrance gates
	Dispatcher efficiency	Agency interview Management surveys
	Decrease in parking lot closures	Management survey Direct observation
	Number of stops at visitor center	Visitor survey System data
	Efficient planning	System data Interview/Focus groups
Environment	Parking lot utilization	Parking study
	Damage to natural sites around parking lots	Direct observation
	Number of vehicles parked off-road	Parking study
	Total animal population	Park records
	Road kill counts	Direct observation
	Noise impacts (campgrounds)	Modeling Field monitoring
	Emissions/Air quality CO, NOx, HC levels	Modeling Field monitoring
	Water quality	Field monitoring
	Impact on polluted runoff on resources	Modeling Field monitoring
	Fuel consumption	Models/Visitor survey
	Vehicle counts	Traffic counts

One MOE is not applicable to all different situations. The review of existing MOEs provided insight into the different measures that were being used worldwide for many different ITS deployments. MOEs need to be tailored to deployments; when deployments differ, the MOEs will also differ. Another important element is location; two identical deployments may require different evaluation strategies based on the location (i.e. national park vs. urban).

As outlined in the previous chapter, the goals and objectives of the transportation system in national parks differ from other settings. There is no perfect fit between one area and national parks because of the diverse nature of national parks; however, a combination of MOEs from all three of the existing categories that were examined, in addition to some new MOEs based on park-specific goals (i.e. in a general management plan), provides a comprehensive list.

The level of transferability between each of the existing areas (rural, urban, and international) and national parks is dependent on a variety of different factors. Many of the MOEs can be easily applied to a national park setting without any modifications. A good example of this is many of the safety MOEs. Measurements of the number of crashes or fatalities are the same in each different setting. Some MOEs, though, may have entirely different requirements between two settings. One example of this is the level of service (LOS) measure. This measure is commonly used to evaluate mobility and utilizes a standard designation of capacity. However, as mentioned previously, the concept of capacity is different in a national park; therefore the existing LOS designation, based on a standard highway capacity, is not applicable and may require additional adjustments. The level of priority of the resource protection goal area in national parks is significantly higher than in urban and rural areas. As a result, there are some MOEs that were developed from this specific goal that were not used elsewhere. An example of this is the total animal population and road kill counts.

These six goal areas do not encompass the only measures that can be used to successfully evaluate ITS deployments in National Parks. It is also important to emphasize the interrelated nature of many of these MOEs; one measure may be used to reflect benefits in several areas. ITS deployments in national parks, over time, may be integrated into the existing infrastructure of the surrounding urban areas and gateway communities to yield maximum benefits. Before this occurs, adequate knowledge of systems within the park should be monitored, recorded and evaluated, and additional MOEs may be needed to accommodate this integration.

7. DATA COLLECTION

The selection of a MOE is based on its relationship to the corresponding ITS application. Additional consideration must be given to the type of data needed to support these selected MOEs and the baseline data that has already been collected and stored. A MOE that requires data that is difficult to quantify or collect is not as effective and may present additional challenges to the evaluation process. Similarly, a measure that looks at the performance of a transportation system after implementation of ITS, but does not have adequate baseline data for comparison, is not as useful.

This section presents a summary of important data collection issues for national parks and the surrounding gateway communities that should be considered as part of the MOE selection process.

7.1. Baseline Data

Baseline data is an essential component of the evaluation process. Existing data must be available for comparison purposes after the initial deployment of ITS. Measures of effectiveness rely on baseline data to gauge the performance and the benefits that can be seen after deployment. Although the quality, quantity and time frame of the baseline data varies among different national parks, most national parks have some relevant archived data. However, this data may not correlate with what is needed to support the specific MOEs that have been selected for a goal area. These factors need to be considered before choosing MOEs. The time frame is another important factor: baseline data needs to be collected over a consistent time frame (i.e. two years before the ITS is in place and two years after the ITS is in place) so that the comparison is meaningful. An outline of expected data collection efforts for future projects and the timeline that it needs to follow is an important output of this study. Even if the existing data does not exist, a clear understanding of what is needed will set the stage for future developments and successful use of the MOEs. As mentioned previously, the unique characteristics of national parks and their surrounding gateway communities contribute to the different level of difficulty related to collecting data within and around the park.

7.2. Data Collection Methods

Measures of effectiveness rely on timely, accurate data collection for their success and may require many different types of data to support them. Restrictions related to funding constraints or resource limitations may make data collection difficult and thus the performance measure will be useless. Clear designations of the type of data to collect, when to collect it, and how it will be documented and stored can alleviate the challenges that may arise. Additional factors can potentially affect the data, including seasonal variations, the differences between local and tourist users, as well as the intended end result (i.e. for park staff or public). Skewed data is ineffective and costly and every effort should be taken to avoid its occurrence. The level of detail of data availability is also dependent on location. Urban areas, for example, will have more extensive baseline data and more resources for additional data collection efforts. A MOE is only as good as the data used to support it. The primary methods for data collection that correspond to the MOEs developed in the previous section are listed below.

7.2.1. Surveys (Management/Visitor)

Visitor experience is a critical goal and the primary method to gauge this satisfaction or dissatisfaction is through the use of surveys. Surveys can be an important tool, but their effectiveness is highly dependent on the survey itself, how the questions are worded and the types of quantifiable information that can be pulled from the questions and corresponding answers. Developing these surveys takes a significant planning effort, both for creating relevant questions and assuring there is adequate baseline data for comparison purposes. Specific challenges for this type of data collection are related to the determination of an appropriate sample size, the difficulties in interpretation of the stated preferences, and the associated costs required to create and administer the surveys. National parks often see a higher return rate of surveys, as compared to other sites. Surveys are used for visitor input, as well as opinions from park managers and staff.

7.2.2. Park Records and Models

Park records and models are another data source for many of the selected MOEs. Each park has its own system for maintaining and documenting records. Visitation statistics are collected for every park, but the level of accuracy may affect the usability for other purposes (i.e. ITS evaluations). Additionally, the extent to which the records are archived and available for other users to access the information may hinder the use of such statistics. There are many different types of records that can be used, including park management records, local law enforcement and police records within the park, as well as police records for surrounding gateway communities. Collection methodologies for data may fluctuate over time or in different locations, resulting in significant impacts on the data and the usability for comparison purposes. Examples of this include visitation statistics and crash data. Specific outlined needs and guidelines for these types of data collection can be developed to provide similar data for comparison and evaluation use.

Simulation models are also used to calculate and display the impact of strategies using mathematical models and collected data. These models can be successful at projecting benefits that may be difficult to collect in the field. Different categories of simulation, including air quality and traffic models, are relatively low in cost and do not require much data. Challenges related to accuracy, the need for calibration and validation, and available technologies may exist.

7.2.3. Direct Observations

Direct observations are typically performed by a trained staff member, field survey or video documentation and may include traffic counts, accident data, and parking statistics. They are conducted over the time of conditions before and after the implementation of ITS deployment. Costs associated with this type of data collection can vary depending on the technical level of expertise required to make the observations. There may be some difficulty obtaining a good representation of data during peak seasons.

7.2.4. Interviews

Interviews of government officials, management staff, community leaders, park partner organizations and concessionaires may provide a general consensus about how a deployment is viewed and other useful subjective information that might go unnoticed in other studies. Also, interviews that include information collected from a sample of the users or others that benefit from the specific deployment may be informative. Typically, it is easier to obtain system-wide, overall objectives and view the whole picture from this effort. This may be especially useful for objectives related to interagency coordination. The benefit is quantifiable data with relatively low costs. Interviews can provide valuable insight; however, similar to surveys, developing questions that do not encourage biased answers can require extensive planning and additional costs.

7.2.5. System Data

System data includes all of the data that is electronically recorded, such as the number of visitors, the amount of money collected over a time period, total wildlife counts, and the costs of incidents. This data has many purposes and is typically already being collected. Many of the MOEs utilize this data to support the evaluation of ITS, which is beneficial because there are no extra costs associated with the data collection. Limitations may exist though, because the data may have been collected with a different purpose in mind. This discrepancy may affect the acceptable level of accuracy for the desired evaluation process.

7.2.6. Gateway Communities' Data

The gateway communities have a significant impact on the transportation system within the national park. Therefore, data collection should also include data sources that are outside of the park. Obtaining this data, such as transit systems data, traffic counts and accident data en-route to the park, and economic impacts from the surrounding communities may require multiple sources. The number of different agencies that are involved expands considerably, as the range of the deployment and the corresponding evaluations increase. As agency involvement increases, resources and collection efforts may increase, but maintaining consistency becomes more difficult and poses a challenge for analysis purposes.

8. EXAMPLES OF NATIONAL PARK ITS DEPLOYMENT EVALUATIONS

The purpose of this paper was to develop MOEs that would have broad applicability to many national parks. This section will provide two examples of how this paper can be used to evaluate a specific ITS deployment. The examples will be taken from the Phase 1 Report for Assessing the Needs of California National Parks (28).

8.1. Golden Gate National Recreation Area

The Golden Gate National Recreation Area (GGNRA) is a large urban park located on two peninsulas between the Pacific Ocean and the San Francisco Bay in northern California. The early winner project for GGNRA is the procurement of two portable changeable message signs for placement north and south of the Manzanita interchange of State Route 1 and Highway 101. This project focuses on real-time traveler information related to congestion at this interchange and parking availability at Stinson Beach and Muir Woods.

Evaluating the effectiveness of this ITS deployment begins with the established goals and objectives of the project. As documented in the GGNRA Feasibility Report the, goals and objectives that correspond to portable changeable message signs all fall under goal one (enhance visitor experience) and include the following objectives:

- Objective 1.1.1: Develop predictive information that will help visitors plan their trips better
- Objective 1.1.2: Provide appropriate information at major transportation decision points
- Objective 1.1.3: Provide information to help visitors avoid congested locations and times
- Objective 1.1.4: Provide weather, road condition, and chain requirement information
- Objective 1.1.5: Provide construction and work zone information
- Objective 1.1.6: Provide information on parking availability
- Objective 1.1.8: Provide air quality information
- Objective 1.2.1: Improve the safety of vehicles at or approaching congested entrance stations
- Objective 1.2.2: Improve the safety of vehicle travel on park roadways
- Objective 1.2.3: Improve the safety of vehicle travel through work zones in the park

These goals and objectives are taken from the complete list outlined in Chapter 5 and as previously discussed, are tied to six specific evaluation goal areas and associated MOEs. From the comprehensive list of MOEs in Section 6.2, the following MOEs have been chosen to evaluate the objectives specified above. These selections are shown below in Table 8-1.

Table 8-1: GGNRA Changeable Message Sign Evaluation

Evaluation Goal Area	MOE	Data Collection
Mobility	Number of delays	Visitor survey
	Location of delays	Visitor survey
	Visitor perception of congestion	Visitor survey
	Management perception of congestion	Management survey
	Variability in travel time between two specific points	Travel time study
Customer Satisfaction	Number of CMS users	Visitor survey
	Number of users reported behavior change (time, mode, destination)	Visitor survey
	Number of users that reported time savings	Visitor survey
	Number of users that reported knowledge of construction/weather conditions	Visitor survey
	Public's acceptability of ITS deployment	Visitor survey
	User acceptance (aesthetics)	Visitor survey
Safety	Increased awareness of potential safety hazards	Visitor survey
	Visitor perception of safety	Visitor survey
	Management perception of safety	Management survey
	Location of incidents	Park police records (within park) Local law enforcement records (outside park)

MOEs were selected from the corresponding evaluation goal areas that represented the specific needs of this individual project. Preliminary data collection requirements were also included and provide an understanding of the data needed to support the MOEs. From these initial recommendations, further consideration can then be given to the development of the individual data collection methods.

Visitor surveys are the primary method of data collection for many of the above mentioned MOEs. The lack of data that outlines visitor satisfaction/dissatisfaction with the park system before the ITS deployment poses a specific challenge with this project. However, researchers can conduct successful collection efforts and formulate effective surveys by identifying the types of data needed to support the evaluation. The anticipated benefits of portable CMS are related to the information provided to travelers on congested areas, and parking availability. Surveys that collect information from visitors regarding time savings, convenience, usefulness of information prior to decision point, and safety should be conducted during the summer and fall, to accommodate the peak visitation.

The safety benefits of this project are much more difficult to quantify. Park police records will indicate an incident location; the primary concern is reduced incidents at entrance gates, resulting from the CMS warnings, however there may be few, if any incidents at that location, thus making a change in incidents difficult to compare. Another important consideration related to safety benefits is the visitor's perception; increased awareness and expectation of congestion may put the traveler at ease and thus contribute to reduced incidents.

8.2. Sequoia and Kings Canyon National Parks

Sequoia and Kings Canyon National Parks (SEKI) are located on the eastern side of the San Joaquin Valley in the Sierra Nevada Mountains. It is a rural park with rugged terrain throughout the park. These specific characteristics contribute to the need for different MOEs and additional challenges to data collection. The early winner project for SEKI is an expanded park-wide radio information system, which focuses on real-time traveler information. As documented in the Phase 1 Report, goals and objectives related to the radio system include:

- Objective 1.1.2: Provide appropriate information at major transportation decision points
- Objective 1.1.3: Provide information to help visitors avoid congested locations and times
- Objective 1.1.4: Provide weather, road condition, and chain requirement information
- Objective 1.1.5: Provide construction and work zone information
- Objective 1.1.6: Provide information on parking availability
- Objective 1.1.7: Provide information at various park sites about transit arrivals and schedules
- Objective 1.1.8: Provide air quality information
- Objective 1.2.1: Improve the safety of vehicles at or approaching congested entrance stations
- Objective 1.4.2: Decrease the difficulty in finding available campsites
- Objective 2.1.3: Promote information about non-automobile alternatives

Applicable MOEs related to these objectives and their corresponding data collection methods are shown below in Table 8-2. They have been selected based on their applicability to the specific project and relationship to the corresponding evaluation goal areas. The early winner projects of SEKI and GGNRA share many of the same themes and benefits because they both address real-time traveler information needs. Some of the MOEs are different, based on specific characteristics of SEKI.

Table 8-2: SEKI Expanded Park Radio System Evaluation

Evaluation Goal Area	MOE	Data Collection
Safety	Increased awareness of potential safety hazards	Visitor survey
	Visitor perception of safety	Visitor survey
	Location of incidents (i.e. entrance gates)	Park police records (within park) Local law enforcement records (outside park)
	Management perception of safety	Management survey
Access	Knowledge of special event information	Visitor survey
	Knowledge of travel options	Visitor survey
Mobility	Improved throughput at entrance gates	Direct observation System data
	Number of delays	Visitor survey
	Location of delays	Visitor survey
	Visitor perception of congestion	Visitor survey
	Management perception of congestion	Management survey
	Variability in travel time between two specific points	Travel time study
	Average speeds through congested areas	Speed study
	Park staff's perception of time savings	Management survey
Customer Satisfaction	Number of radio users	Visitor survey
	Number of users reported behavior change (time, mode, destination)	Visitor survey
	Number of users that reported time savings	Visitor survey
	Number of users that reported knowledge of construction/weather conditions	Visitor survey
	Public's acceptability of ITS deployment	Visitor survey
	User acceptance (aesthetics)	Visitor survey

Many of these MOEs rely on visitor and management surveys to obtain data to support the evaluation efforts. Ideally, surveys before and after the expansion of the radio system should be conducted. If this is not possible, the survey performed after the upgrade may include questions about prior use of the radio system. The park radio system has more flexibility with respect to the type of information that can be conveyed to visitors. Information regarding access to special events and other attractions is a specialized benefit unique to SEKI. Also, as alternative transportation modes, such as shuttles, are integrated into the transportation system, additional survey questions related to knowledge of transit should be included. Although the MOEs listed above represent the main areas of evaluation, other measures that are specifically related to the

ITS technology also need to be considered. The number of hours of broadcast, and the number of messages before and after the system upgrade can indicate the success of the system.

9. SUMMARY AND RECOMMENDATIONS FOR FURTHER RESEARCH

9.1. Summary

National parks and their surrounding gateway communities have specialized needs related to their transportation systems. As the need for innovative transportation solutions in national parks becomes more critical, ITS applications have become more common. This paper has highlighted the importance of an evaluation plan and provided a preliminary examination of how the benefits of ITS may be measured. Sharing and storing evaluation results based on a standardized set of guidelines may be difficult for the wide range of national parks and their individual needs, but there is some level of transferability within the parks. As time goes on and there is greater experience with application of ITS in national parks, more contributions to what works and what does not work will enhance the strength of this research.

In general, however, MOEs must be selected on a case by case situation and a MOE that is effective in one scenario might not be as effective in a different application. Each deployment needs special attention to tailor MOEs to fit the national park, similar to the way the MOEs for national parks were modified from the Federal guidelines. Determining specific goal areas that are broad enough to encompass many different applications is the most effective evaluation method. Even though these areas have been determined for use in national parks, individual deployments will have different needs, and these suggested MOEs may need further modification. An effective MOE should be proposed, discussed and refined throughout the whole life of the project. Park management needs to use a flexible evaluation plan and participate in continual reviews of goals and objectives to achieve continued success.

As deployments increase in national parks and the benefits become more visible, the next step will be the integration and coordination of such systems into the surrounding gateway communities, and further still into nearby urban centers. Also, the potential for connecting nearby park units to enhance the ease of travel for visitors is promising. Visitors are more likely to support ITS if these technologies are marketed towards meeting their travel needs; determining the benefits and directly relating them to the customer will be critical to ensure public support. There are a large number of possibilities and as successful evaluation plans prove the benefits of successful deployments, the desire to try new things and expand the benefits will certainly be investigated.

9.2. Recommendations for Further Research

ITS deployments in national parks are a relatively new concept and further research is recommended to explore how these technologies can be modified to fit into a national park setting, and what specific measures can be taken to ensure they are appropriate to the local environments. Additionally, the evaluation process is highly dependent on data collection and there are many opportunities for further research to enhance the existing methods, documentation and sharing of data.

<u>Unified Database</u>: All evaluations require some level of data; depending on the magnitude of the project, the data requirements may differ. Many national park units are located close together and the gateway communities and transportation systems that connect the units can all benefit from an integrated ITS infrastructure. There is a need for additional research related to

developing a unified database for information that can be shared among national parks, specifically for those parks located close geographically, but also parks that may have similar classifications (i.e. rural vs. urban). Data can be costly in terms of time, money and resources and utilizing shared information can stretch limited budgets further.

Selecting a Few Good Measures for National Parks: At the national level, JPO has developed a few good measures that have been successful at tracking ITS deployments. The measures are an efficient use of resources and a good starting point for many evaluations. Selecting a few measures that are tied to the underlying mission of the NPS at this point is difficult. The diversity of national parks and the limited ITS deployment experience contributes to this difficulty. In the future, as ITS becomes more widespread in national parks and the surrounding communities, further research may present a few measures that can be used in a similar fashion to the national few good measures.

Visitor Surveys and Qualitative Data: Many of the MOEs that have been established for evaluation in national parks are closely related to visitor satisfaction. Customer satisfaction is a qualitative measure that can not explicitly be assigned a dollar value, but is an important contribution to the evaluation process. Incorporating this qualitative data into a usable form that can easily be applied to justify the benefits of ITS deployments will be important to the future of ITS. Surveys are the most effective method for gauging user satisfaction or dissatisfaction. Developing surveys requires a significant planning effort and investment and often the return rate for surveys is far below acceptable levels, contributing to the ineffectiveness of the evaluation process. Further investigation into the distribution of surveys, and possible incentives for returned surveys could also greatly benefit the evaluation of ITS deployments.

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