Final Report

GREAT SMOKY MOUNTAINS INTELLIGENT TRANSPORTATION SYSTEM (ITS)

VOLUME I of II: GRSM ITS STRATEGIC PLAN

PROJECT NAME:
GREAT SMOKY MOUNTAINS NATIONAL PARK
ITS Strategic Deployment Plan
Contract # DTFH71-02-00040

PREPARED FOR:
NATIONAL PARK SERVICE AND
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

December, 2007

This report contains Stakeholder comments and opinions that do not necessarily reflect the views of the National Park Service, Federal Highway Administration-Eastern Federal Lands or Wilbur Smith Associates.

EXECUTIVE SUMMARY

The National Park Service (NPS) in association with the Federal Highway Administration (FHWA), Eastern Federal Lands Highway Division, directed completion of this Strategic Intelligent Transportation System (ITS) Deployment Plan for the Great Smoky Mountain National Park (GRSM). The GRSM straddles the border between the states of Tennessee and North Carolina, and is one of the most heavily visited parks in the NPS. This work was conducted to determine how ITS in and around GRSM could be implemented and operationally coordinated over a period of time. Establishing a framework for the park, the ITS Deployment Plan aims to "link" both in-park and surrounding community ITS activities with other regional and statewide ITS activities in Tennessee and North Carolina.

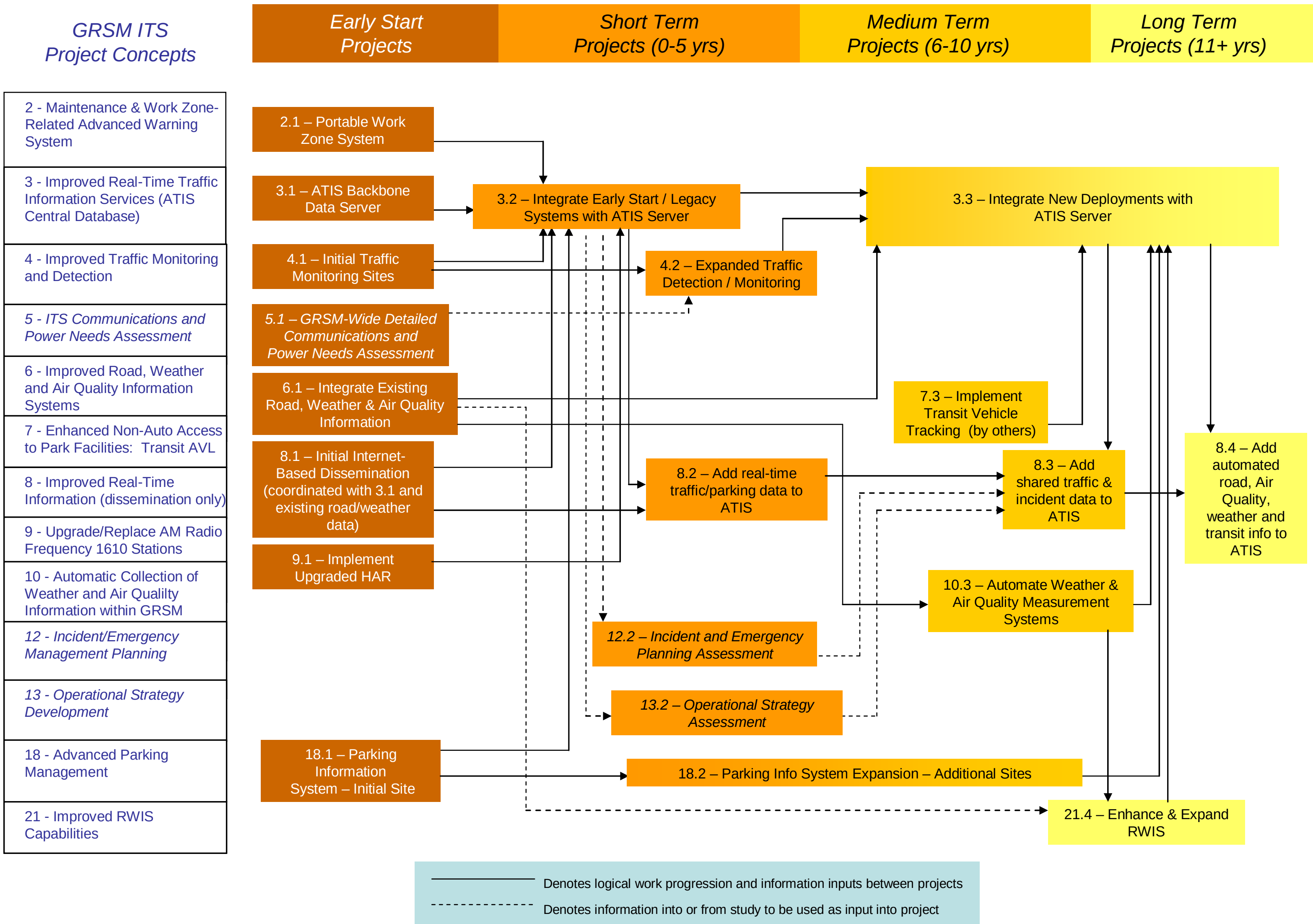
The result of this effort is a two volume set that includes this Volume I, *GRSM Strategic ITS Plan*, and Volume II, *GRSM ITS Architecture.* Volume I focuses on plan process, project concept development and prioritization, leading to a list of recommended ITS projects for transportation safety and operations while fully embracing the park's natural environment. Volume II on ITS architecture lays the necessary foundation to ensure that design, deployment and operations of ITS subsystems are fully in conformance with FHWA requirements for federal funding. Volume II also explores institutional agreements and technical integration for ITS projects, addressing the greater regional context of Tennessee and North Carolina. Additional documents are available from FHWA that lay out all project work in greater detail.

This project began in May 2003, and relied on extensive stakeholder involvement, given the many diverse interests engaged in the GRSM environment and activities. Major stakeholders (see Section A. –V. for a complete list) represented the GRSM Divisions, Tennessee and North Carolina State Transportation Departments, the Federal Highway Administration, Gateway cities and counties and planning organizations, and transit operators.

A Steering Committee and a Core Team guided the project consultant (Wilbur Smith Associates, or WSA) in project completion. The Core Team was made up of GRSM NPS, FHWA and WSA personnel. In all, seven Stakeholder Meetings and an ITS Workshop were held. In addition to helping to set vision, develop strategies and generate projects, the meetings brought together the many park interests in a common forum. This provided the opportunity to air viewpoints, discuss needs and work towards common ends. The working spirit of cooperativeness among the diverse interests is one of the major benefits of the entire study effort, a spirit that should be nurtured and supported as the park considers and pursues ITS implementation.

Project tasks were directed at meeting the goal of laying out a road map for ITS deployment for GRSM. After reviewing existing conditions, ITS themes were defined, followed by plan objectives, then ITS strategies. From the strategies, 26 initial ITS Project Concepts were developed. These were reviewed and refined into 14 high priority concepts, one of which was advanced by the park outside this study. The 13 remaining concepts then generated 20 ITS projects falling into four implementation time frames: Early Start (8 projects), Short Term (6 projects), Medium Term (4 projects) and Long Term (2 projects). The graphic on the next page illustrates these 20 projects by time frame for implementation and indicates linkages.

GREAT SMOKY MOUNTAINS NATIONAL PARK ITS DEPLOYMENT STRATEGY



The eight Early Start projects were developed through conceptual design, including key functional elements and cost estimates. In total, the eight projects would cost an estimated $ 2.34 Million to implement, as follows:

Project	Cost (000s)
• 2.1 Portable Work Zone System	$ 266
• 3.1 ATIS Backbone Data Server	$ 225
• 4.1 Initial Traffic Monitoring Sites	$ 520
• 5.1 GRSM-Wide Detailed Communications and Power Needs Assessment	$ 300
• 6.1 Integrate Existing Road Weather & Air Quality Information	$ 121
• 8.1 Initial Internet-Based Dissemination (coordinated with 3.1 & 6.1)	$ 133
• 9.1 Implement Upgraded HAR	$ 495
• 18.1 Parking Information System – Initial Site	$ 276

The GRSM Park then selected the following three for additional analysis, to refine conceptual design and cost: 3.1, 4.1 and 8.1. The additional work on these three provides a complete basis to pursue federal funding and other funding sources. The potential funding sources discussed range from federal and local programs, to private funding and innovative approaches.

The 20 projects developed thus far constitute an initial ITS Plan for GRSM. This report provides the background and basis for future development of additional ITS projects that would be part of a broader GRSM ITS plan, based on the perceived needs of project Stakeholders.

Along with development of the project list and priorities, a parallel activity was the development of an ITS Architecture for GRSM, in conformance with program requirements of the USDOT National ITS Architecture. The National Architecture calls for a structured, comprehensive approach to define vision, concepts, requirements, user services and supporting market packages, equipment packages and process specifications. Since 2001, it has been a Federal requirement that regions and major projects have formally developed architectures in order to qualify for Federal funding. To be in conformance, this project has followed the prescribed steps. Volume II of this two volume set provides more detailed documentation of the GRSM ITS Architecture. The supporting electronic files are also available.

At present, the key follow-up activity is to actively seek out the funding options and move projects into design and implementation. In addition, the adjacent regional architectures in Tennessee (the Knoxville ITS Regional Architecture and the Tennessee Statewide ITS Architecture) and in North Carolina (Western Region) should formally incorporate aspects of the GRSM ITS Architecture. This will facilitate and support the grant and funding application process. In the same vein, it is recommended that Steering Committee Member agencies at a minimum stay in active contact to advance projects with regional implications, discuss further needs and coordinate efforts.

This plan is intended to be a living document. Elements within the plan need to be updated as improvements are made to the park, including the project list and the GRSM ITS Architecture.

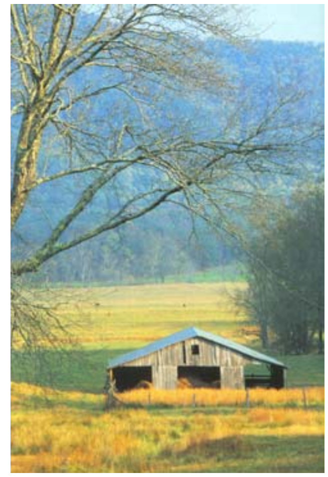
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Section A: Project Purpose and Process

I. INTRODUCTION AND BACKGROUND



The National Park Service (NPS) and FHWA Eastern Federal Lands Highway Division (EFLHD) has completed a Strategic Intelligent Transportation System (ITS) Plan for the Great Smoky Mountains National Park (GRSM). This overall goal has been to determine how ITS in and around GRSM should be implemented and operationally coordinated over a period of time. The plan establishes an ITS framework for the GRSM, consistent with the National ITS Architecture and compatible with the regional architectures of Tennessee and North Carolina, which are evolving. The plan has also evaluated institutional, operational, and management activities needed to implement the architecture. The Strategic ITS Plan is envisioned to be an integral part of the regional ITS Programs, providing continuity of information and operation.

GRSM is one of the most visited national parks in the United States, attracting between 9 and 10 million visitors per year for hiking, picnicking, camping, fishing, biking, and horseback riding. Within its 521,000 acres of land lie unequaled plant and animal life and a large collection of historical structures. The park accordingly faces many transportation challenges, yet has physical constraints, plus aesthetic and resource considerations that prevent it from simply building new roads or adding lanes. ITS, or the integrated use of advanced electronic and communications technology to improve efficiency and safety, is viewed as perhaps the best way to improve park transportation without building new roads or adversely impacting precious natural resources. An initial set of four themes recognizing the essential character of GRSM has guided the Strategic ITS Plan.

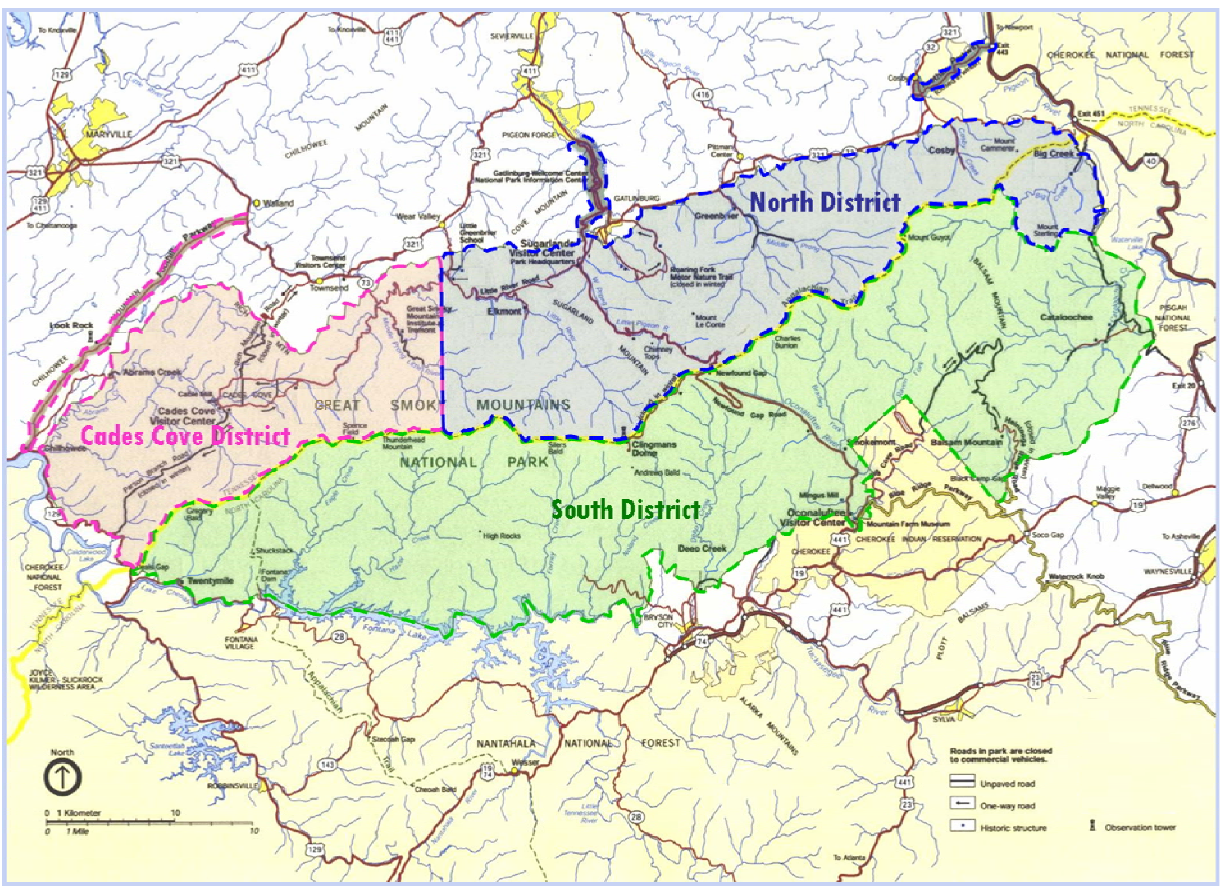
This plan has followed the procedural guidelines of the Federal Highway Administration for ITS planning, and is the result of a comprehensive stakeholder involvement effort. The plan offers sufficient guidance for GRSM to carry future projects forward through systems engineering into implementation. To assist in preparation, the NPS and EFLHD employed Wilbur Smith Associates (WSA) to coordinate and lead several plan activities, and to assemble the final report.

A Steering Committee and a Core Team directed project completion. The Core Group was made up of NPS, FHWA and consultant team personnel. Over 30 Stakeholders participated as well, representing a broad spectrum of interests in the park and its environs. Additional Interested Parties took part in key activities. In all, seven Stakeholder Meetings and one ITS Workshop were held. In addition to helping to set vision, goals and developing projects, the meetings brought together the many park interests in a common forum, providing the opportunity to air viewpoints, discuss needs and work towards common ends.

The plan region has been described as "in and around the park" and "an integral part of the Tennessee and North Carolina regional ITS programs", with the primary focus being the park and immediately adjacent lands, and secondary focus being the Tennessee and North Carolina regional systems and local networks affected by and affecting the park operations. Figure 1 sets the regional context, while Figure 2 illustrates the three operational park districts.

FIGURE 1. REGIONAL SETTING

FIGURE 2. GRSM PARK DISTRICTS



II. GRSM ORGANIZATIONAL STRUCTURE

GRSM has a **Superintendent** who is responsible for all park operations as illustrated in **Figure 3**. The Assistant Superintendent, Management Assistant, Safety and Occupational Health Manager, Concessions Management Specialist, and five divisions are under the Superintendent. Those divisions include Administration, Resource and Visitor Protection, Resource Education, Maintenance, and Resource Management and Science.

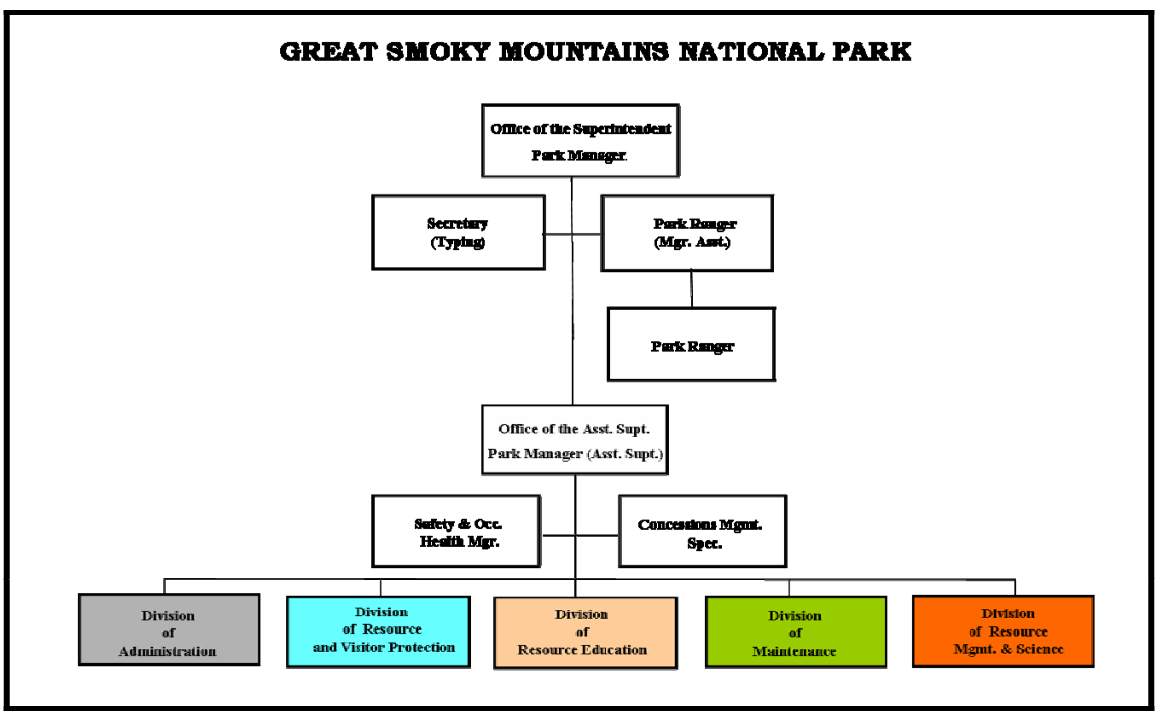
The Division of **Resource and Visitor Protection** is responsible for all law enforcement and emergency response and is divided into the Tennessee and North Carolina Operations. Within the Tennessee Operations section are the Cades Cove and North Districts. The North Carolina operations are defined as the South District.

Resource Education has a division chief who is supported by park rangers overseeing the North, South, and Cades Cove Districts. Furthermore, this division has a staff park ranger and a supervisory park ranger in charge of the parks as Classroom Program.

The major components of the Division of **Maintenance** include the Facility Manager, the Program Manager, the Budget Analyst, and the division for professional services. Under Professional Services is the technical support staff with landscape architecture, engineering, or transportation planning backgrounds.

Finally, the **Resource Management and Science** Division has a division chief who is supported by the Natural and Cultural Resources Branches, the Inventory and Monitoring Branch, and the Fire Management Branch.

FIGURE 3. ORGANIZATIONAL STRUCTURE



III. GRSM ITS PLANNING PROCESS

A. Project Tasks

The overall project scope included eight major tasks as follows:

- TASK 1 – STUDY MOBILIZATION
- TASK 2 – DEVELOP ITS THEMES
- TASK 3 – DEFINE PROBLEMS & OPPORTUNITIES
- TASK 4 – DEFINE ITS STRATEGIES
- TASK 5 – IDENTIFY CONCEPTS
- TASK 6 – DEVELOP ITS ARCHITECTURE
- TASK 7 - IMPLEMENTATION REQUIREMENTS
- TASK 8 – ITS STRATEGIC DEPLOYMENT PLAN

The various tasks resulted in several documents including the following:

- *Consensus Building Work Plan* (Task 1)
- *Working Paper #1: ITS Themes and Condition Assessment* (Tasks 2 & 3)
- *Working Paper #2: ITS Strategies Report* (Task 4)
- *Working Paper #3: ITS Architecture and Initial Project Concept* (Task 5 & 6)
- *Final Report (Volumes I & II)* (Tasks 7 & 8)

This two volume final report summarizes the prior documents, in addition to addressing Tasks 7 and 8. The prior documents present, step-by-step, the detailed project work. They are available from the Federal Highway Administration by contacting Mr. Frank Corrado, 703-404-6372 (frank.corrado@fhwa.dot.gov).

B. Decision Process

A consensus building work plan was developed with the purpose of creating and maintaining an environment for effectively and efficiently reaching consensus decisions while gaining input from a wide variety of local government entities that may be impacted by project decisions. The overall purpose of the consensus building and outreach plan was to identify and prioritize desirable ITS services to respond to the park-related transportation challenges

The plan identifies who, where and how final decisions were to be made on this project by the government members of the Core Team. Products that result from this project are ultimately recommendations submitted to the NPS for further consideration. To achieve final decisions and to arrive at consensus-based decisions, input was received, then referred to the project's Steering Committee who then makes recommendations to the Core Team.

GRSM National Park Service is fortunate to have a strong multi-county network in Tennessee and North Carolina to help facilitate a comprehensive consensus building effort to support the ITS Deployment Plan. The outreach network included the six counties bordering the GRSM: Tennessee counties Blount, Cocke and Sevier; North Carolina counties Swain, Graham and Haywood.

C. Project Participation

The active members necessary to conduct project activities are grouped according to project roles and responsibilities. The four groups identified for this project are the Core Team, Steering Committee, Stakeholders, and Interested Parties. Each group has fulfilled necessary components throughout the project activities toward developing a consensus-based project outcome.

The **Core Team** guided the multi-disciplinary ITS strategic planning process. This Core Team is composed of the FHWA Eastern Federal Lands Highway Division ITS Specialist and Contracting Officer's Technical Representative, Great Smoky Mountains National Park designated Project/Task Manager and Program Manager, and the key project staff of Wilbur Smith Associates (Consultants). The Core Team members were responsible for all project activities, overall project delivery, progress reporting, contractual adherence, invoicing and payments. The Core Team consisted of the following individuals:

Core Team

Frank Corrado, P.E., PTOE Traffic Operations Engineer / ITS Specialist Federal Highway Administration Eastern Federal Lands Highway Division	Dianne Flaugh Landscape Architect Great Smoky Mountains National Park
James Powell, P.E., PTOE * Central Region ITS Director Wilbur Smith Associates	Teresa Cantrell, Program Manager Great Smoky Mountains National Park
Hollis Loveday Senior Transportation Engineer Wilbur Smith Associates	Ronald Wolcott, Vice President, National Director of ITS Services Wilbur Smith Associates

* Martha Morecock Eddy was the consultant Project Manager (PM) from 2003 through August 2007, at which time James Powell took over as WSA PM.

The **Steering Committee** included members of the Core Team as well as consultants and organizational representatives identified in the following list. The Steering Committee received input from the Stakeholders and Interested Parties, provided input to public sector Core Team members regarding project direction and activities, made recommendations to the Core Team, and had knowledge of project activities and documents prior to meeting presentations. Decisions made during Steering Committee meetings were done so by majority agreement made after presentation and discussion of issues. The consulting team prepared meeting materials (based on direction of the Core Team) and led the Steering Committee through presentations and discussions of project material. Steering Committee input was referred to the Core Team to direct the consulting team. The Steering Committee members are listed on the next page.

Steering Committee

Alan Sumeriski Chief of Facility Management Great Smoky Mountains National Park	Mark Best Tennessee Department of Transportation District Traffic Engineer-Region One
Barak Myers Cherokee Department of Transportation	Assistant Design Director Tennessee Department of Transportation
Vinit Deshpande, Transportation Analyst Wilbur Smith Associates	Dawn Ford, Assistant Outreach Manager Hall Communications, Inc.
Greg Fuller, State ITS & Signals Engineer North Carolina Department of Transportation	Caroline M. Runser-Turner, RPO Coordinator Land to Sky Regional Council
John Gould, Senior Traffic Engineer Wilbur Smith Associates	Frances W. Hall, Outreach Manager Hall Communications, Inc.
Ryan Sherby, Southwestern Commission (Western 7 counties, rural planning organization functions)	Bob Miller, Public Information Officer Great Smoky Mountains National Park
Reuben Moore, Operation Engineer North Carolina Department of Transportation	Donald Gedge, ITS Engineer Federal Highway Administration Tennessee Division
Brad Hibbs, Research & Technology Engineer Federal Highway Administration North Carolina Division	Jeff Welch, Executive Director Knoxville Urban Area Transportation Planning Organization

Stakeholders consisted of Core Team members, Steering Committee members and the representatives identified in the following list. Stakeholders provided input on project activities because they could be affected by the project's outcomes. Stakeholders also reviewed material presented at the meetings. One primary mechanism that was used to generate consensus was the use of break-out groups at stakeholder meetings and an ITS workshop (discussed below). The break-out groups were tasked to generate valuable project input for consideration by the Steering Committee.

While in the break-out groups a facilitator guided the group through periods of open discussion, identification of advantages and disadvantages, and brainstorming to fulfill the group's purpose. A number of techniques were deployed by the facilitator to arrive at necessary input to the Steering Committee.

Stakeholder representatives were as follows:

Stakeholders

J. David Anderson Blue Ridge Parkway	David Ball, Planner City of Gatlinburg
Doug Bishop City Administrator, Sevierville	Tim Barth Town Manager, Maggie Valley, North Carolina
Larry Callicutt Bryson City Manager	Finance Department Graham County
Lynda Doucette, Supervisory Ranger Great Smoky Mountains National Park	Sherry Spicer-Dudley, City Recorder Pittman Center, TN
Lee Galloway, City Manager Waynesville, NC	Herb Handly Tuckaleechee Cove Advisory Board
Jerry Hickman, City Engineer City of Sevierville	Elizabeth Honeycutt North Carolina Department of Transportation
Rick Honeycutt, County Manager Haywood County, North Carolina	Gary Horne, Computer Specialist Great Smoky Mountains National Park
Kevin King, County Administrator, Swain County, NC	John Lamb Blount County, TN
Safety/ Concession Manager Great Smoky Mountains National Park	Scott Marine, Director Pigeon Forge Fun Time Trolley
Iliff McMahan, Jr. Cocke County, TN	Mark Miller, Public Works Director City of Pigeon Forge
Bill D. Noland, Chairman Board of Haywood County Commissioners	Joanne Oerter, North Carolina 511 North Carolina Department of Transportation
Cindy Ogle, City Manager, Gatlinburg, TN	Buddy Parton, Director Gatlinburg Mass Transit
Shannon Skidmore Town of Townsend Mayor	Lisa Slobodzian Great Smoky Mountains National Park
Earlene Teaster Pigeon Forge City Manager	Larry Waters Sevier County Mayor
Jerry Cunningham Blount County Mayor	John Jagger City of Pigeon Forge
Ron Hancock, PE, Constr. Operations Engr North Carolina Department of Transportation	Glenn Jones, Chairman Swain County Commission
Karl Kreis City of Pigeon Forge	Ken Mills, EDC Coordinator Swain County Economic Development
Judy Steele TNDOT Community Relations Director	Teresa Estes TNDOT Long Range Planning
Travis Brickey TNDOT Region 1 Communications & Community Relations Officer	

The final group was **Interested Parties**. This group of individuals and organizations is recognized has having an interest in the park and ITS efforts. To enhance the potential for successful implementation of ITS projects in the park, these parties should be engaged by the park. Interested Parties included elected officials, the general public, and any concerned individuals identified during the planning process. A variety of outreach methods could be used to reach the general public in the future including local media outlets (television, radio and print) in both Tennessee and North Carolina. The list of interested parties developed throughout the course of project work is as follows:

Interested Parties

Great Smoky Mountain Association	Gatlinburg Gateway Foundation
E-911 Office, Sevierville, TN 377	E-911 Office, Swain County, NC
North Carolina I-40 Welcome Center	E-911 Office, Blount County, TN
Pigeon Forge Department of Tourism	Friends of the Smokies
Sevierville Chamber of Commerce and Welcome Center	Smoky Mountain Tourist Council
Tennessee Smokies	Duke Power (Nantahala Area)
Blount County Chamber of Commerce	Gatlinburg Visitor Center
Haywood County Tourism	Gatlinburg Department of Tourism
Cherokee Tribal Travel and Promotion	Pigeon Forge Chamber of Commerce
Harrahs Casino	I-26 Welcome Center
Townsend Visitors Center/ Smoky Mountains Visitors Bureau	AAA East Tennessee
Cocke County Chamber of Commerce	Dollywood
Tennessee Department of Transportation Region One	Haywood EMC Payment Center
Sevierville Lodging Association	Gatlinburg Lodging Association
Pigeon Forge Lodging Association	Retail Merchants Association
Progress Energy Carolinas, Inc.	TN Department of Tourism
Sierra Club of the Great Smoky Mountains	Smoky Mountain Hiking Association
National Park Conservation Association	Cherokee Historical Association
North Carolina Department of Tourism	Bell South, Federal Group Service
Sevier County Electric System	Fort Loudoun Electric Cooperative
Newport Utilities Board	Verizon (phone company)
Gatlinburg Chamber of Commerce	Cosby Business Association

D. Project Meetings

The **Core Team Meetings** were held periodically to discuss the project's progress. Meeting discussions included project progress, invoicing issues, and a review of outstanding action items from previous meetings. Action items and noteworthy discussions as a result of the progress meetings were captured in meeting minutes. The meeting minutes were distributed among the Core Team members. Progress meetings were conducted in person or via teleconference.

Six (6) **Steering Committee Meetings** were originally scheduled to occur approximately once every two months to discuss the project's progress and to gather information necessary to progress the project's development. This schedule was followed for about the first five meetings, but the project was put on hold for about 18 months starting in 2004. Steering Committee meetings were scheduled for the morning of the Stakeholder meetings. Notifications were made within one to two weeks prior to the scheduled meeting. Meeting notifications were electronic or via USPS mail and contained a preliminary agenda and material to be presented at the meeting.

The preliminary meeting materials were reviewed by the Steering Committee members prior to the meeting so that time spent in the meeting focused on the developing project materials. Attendance responses were typically included for these meetings. Action items, conclusions, and noteworthy discussions as a result of the meeting were captured in meeting summaries. Meeting summaries were distributed among all Steering Committee members with meeting presentation and discussion materials attached. Meeting dates and locations are presented below.

The first Steering Committee meeting included a brief "What is ITS?" presentation. The "typical" remaining Steering Committee meetings included:

- Project status
- Meeting material and discussions
- Review of information shared prior to the Stakeholder Meeting
- Any updates on Stakeholder systems and activities

The Steering Committee was provided a report on the planning progress to date and a review of what was to be accomplished during the afternoon Stakeholder Meeting.

Six (6) **Stakeholder Meetings** likewise were originally scheduled to occur approximately once every two months to present the project's progress and to gather information necessary to progress the project's development. Actual meeting dates followed overall project progress, as discussed. Stakeholder meetings were typically scheduled for the afternoon of the Steering Committee meetings. Notifications were made within one week prior to the scheduled meeting. Meeting notifications were electronic or via USPS.

The preliminary meeting agenda was included with the meeting notification. Attendance responses were typically included for these meetings. Action items, conclusions, and noteworthy discussions as a result of the meeting were captured in a meeting summary. Meeting summaries were distributed among the Stakeholder members with meeting presentation and discussion materials attached.

The Stakeholder meeting usually included a brief presentation on the overview of the progress to date and frame the work task for the break-out groups that must be accomplished by the close of the day's activities. The afternoon meeting's aim was to utilize the group structure to focus on issues at hand. Steering Committee members were asked to take a leadership role during the break-out sessions.

A key outreach activity was a two-day **ITS Workshop** conducted by the Western Transportation Institute (WTI) – Montana State University with funding provided by the USDOT ITS Peer-to Peer Program. The workshop was hosted by the FHWA and NPS and was held on October 7 and 8, 2003, in Gatlinburg, TN. Invitations were sent to all project participants. A Steering Committee Meeting followed the workshop on October 9 in Tennessee. The Workshop's presentation materials were supported by up-to-date project material development by the WSA consultant team. The purpose of the workshop was to stimulate effective dialogue and assist the project participants in developing ITS Strategies through "brainstorming" and related workshop activities. The highlights of this ITS Workshop are presented in Appendix A.

Dates and locations of both Steering Committee and Stakeholder meetings were as follows:

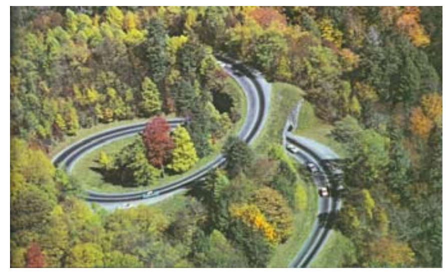
Date	Meeting	Location
June 24, 2003	Stakeholder/Steering Committee Meeting #1	GRSM Sugarlands, TN
August 19, 2003	Stakeholder Meeting #2	Gatlinburg, TN
August 19, 2003	Steering Committee #2	GRSM Sugarlands TN
October 7-8, 2003	ITS Workshop (Meeting #3)	Gatlinburg, TN
December 16, 2003	Stakeholder Meeting #4	Sylva, NC
December 16, 2003	Steering Committee Meeting #4	Sylva, NC
April 7, 2004	Stakeholder Meeting #5	Cherokee, NC
April 7, 2004	Steering Committee Meeting #5	GRSM Oconaluftee, NC
April 11, 2006	Stakeholder Meeting #6	Pigeon Forge, TN
April 11, 2006	Steering Committee Meeting #6	Pigeon Forge, TN
October 30, 2007	Stakeholder Meeting #7 Steering Committee Meeting #7	Cherokee, NC

Section B: ITS Themes and Condition Assessment

I. INVENTORY OF TRANSPORTATION FACILITIES AND FEATURES

This section describes the existing transportation system in GRSM including the road network, road safety, equipment, and organizational structure.

A. GRSM Road Network

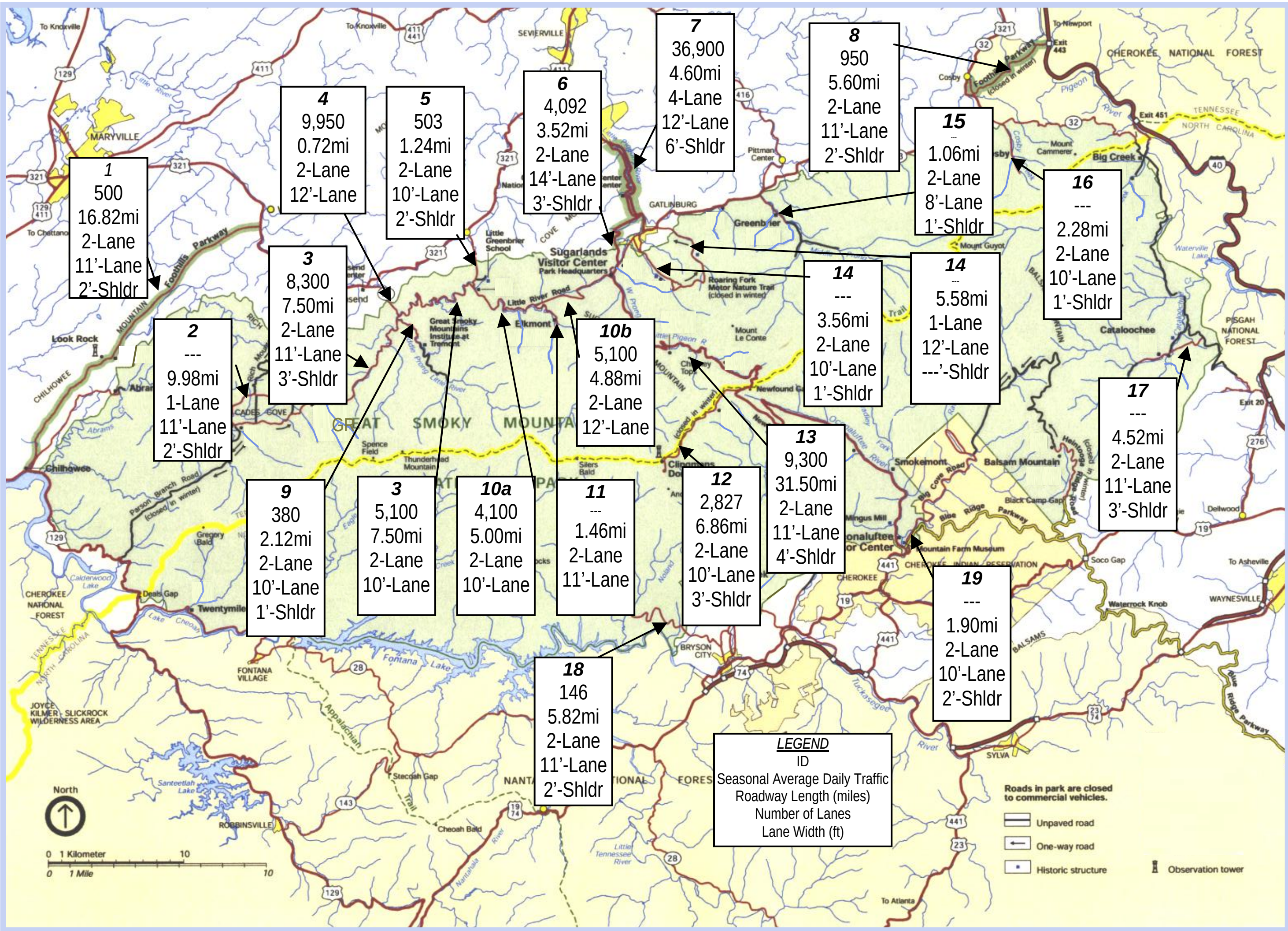


For such a large park, the GRSM road network is relatively simple and spare. A stakeholder at the August 19, 2003, stakeholder meeting said that it is the most visited park in the U.S., yet 95 percent of the visitation occurs in 5 percent of the park. Primary roads within the main park boundary of GRSM include Newfound Gap Road linking the two discontinuous sections of US 441, Little River Road linking the Sugarlands Visitor Center to the Wye and Townsend entrance to the park, Laurel Creek Road which links the Wye with Cades Cove, and the Cades Cove Loop Road.

Figure 4 illustrates GRSM roadway network as well as traffic and cross-section data on all paved roads. Newfound Gap Road accommodates about 9,300 vehicles per day (vpd) during a typical summer day on two 11-foot lanes with 4-foot shoulders. Its total length is 31.5 miles. Little River Road is only 20 feet wide without shoulders, but it accommodates between 4,100 and 5,100 vpd on a typical summer day. It is about 12.5 miles in length. Two other roads inside the main GRSM boundary accommodate a significant amount of traffic including Laurel Creek Road with 8,300 vpd on 11-foot lanes with 3-foot shoulders and the Cades Cove Loop Road with an average seasonal volume of 3,500 vpd on a one-way 11-foot lane with 2-foot shoulders.

Outside the main GRSM boundary, the 4.60-mile Spur between Pigeon Forge and Gatlinburg is a 4-lane (12-foot lane width with 6-foot shoulders) roadway which has a summer daily traffic volume of 36,900. The Gatlinburg By-Pass, another park road outside the main boundary, carries 4,100 vpd on a typical summer day. This road is just over 3.5 miles long and contains two 14-foot lanes with 3-foot shoulders.

FIGURE 4. GRSM PARK ROADWAY INVENTORY



ROAD KEY

1 – Foothill Parkway(west)
2 – Cades Cove Loop Road
3 – Laurel Creek Road
4 – Townsend Entrance Road
5 – Wear Cove Gap Road
6 – Gatlinburg Bypass
7 – US 441/Gatlinburg Spur
8 – Foothills Parkway (east)
9 – Tremont Road
10a – Little River Road
10b – Fighting Creek Gap Rd *
11 – Elkmont Road
12 – Clingman's Dome Road
13 – Newfound Gap Road
14 – Roaring Fork Motor Nature Trail
15– Greenbrier Road
16 – Cosby Entrance Road
17– Cataloochee Entrance Rd
18 – Lake View Road
19 – Big Cove Road

** Commonly known as Little River Road throughout GRSM.*

B. GRSM Equipment Inventory

The following paragraphs list equipment available to GRSM for incident management, data gathering, and communications.

Law Enforcement – The park uses approximately 40 marked law enforcement sedans, sport utility vehicles (SUVs), and pickups equipped with lights, sirens, and radios for road patrol and emergency response situations.

Snow Removal – GRSM has the following snow removal equipment.

Snow Removal and Fire Equipment (September 2003): The park has a number of trucks and support vehicles for snow removal and fire fighting. These consist of 15 dump trucks, 4 graders, 2 fire trucks, 2, front-end loaders, 2 pick-ups and 1 multi-use bulldozer.

Road Weather Information Systems – The National Weather Service routinely sends GRSM updates on weather conditions and search and rescue missions. This information is then shared via radio with park rangers, visitor centers, campground sites, and other areas of high visitor concentrations. GRSM also issues a daily weather report to park rangers and at key visitor designations. Weather and road condition information is also available from the GRSM general telephone number and website. There are five official locations in the park where weather information (temp and rainfall) is collected. None of these are automated and require a person to stop at the location and read the information. The information is posted on the GRSM website. The locations are LeConte, Newfound Gap, Oconaluftee, Sugarlands, and Cades Cove. The information is also sent to the National Weather Service. There are other monitoring stations in the park to collect data such as air quality.

Communications Systems – The Division of Resource and Visitor Protection has a law enforcement dispatch computer system called Tennessee Information Enforcement System (TIES) that is connected to law enforcement, National Weather Service, and Federal and State information systems. An extensive two-way radio system exists within GRSM that includes park headquarters, all law enforcement vehicles, all maintenance vehicles, and most other vehicles. Programming and operation of two Dynamic Message Signs (DMS) is performed in the Communications Center at Park Headquarters. Plans call for the GRSM communication system to eventually be connected to the AMBER Alert Network.

Traveler Information Systems – Two Dynamic Message Signs (see below) are in place to advise motorists of important information regarding park conditions and activities. One sign is located in the southbound direction near the Sugarlands Visitor Center. The second sign is located northbound at the park entrance in North Carolina. Programming and operation of the two Dynamic Message Signs (DMS) occurs in the Communications Center at Park Headquarters.

Highway Advisory Radio (HAR) using AM radio frequency 1610 is used, with limited success, to disseminate general park information to motorists. The equipment is old and not well maintained because replacement parts are no longer available. For those that do work, the message usually pertains to resources or visitor activities. However, at Sugarlands and Oconaluftee the messages often contain Newfound Gap Road conditions. The only two operating units are located at Greenbrier and Oconaluftee, and the Resource Education Division is responsible for changing the messages at these two. Non-operational units are located at headquarters, Cosby, Cataloochee, Deepcreek, Lookrock, Townsend Wye, Cades Cove, Elkmont, Clingman's Dome and Newfound Gap.

GRSM DMS

GRSM HAR Advisory Sign

Traffic Surveillance and Counting Equipment – Primary park portal traffic counts are made via inductive loops year-round and sent to the NPS Field Operations Technical Support Center (FOTSC), based in Denver for processing, summary, and storage. An inductive loop counter has also been installed on the north end of the Spur. The FOTSC maintains a Traffic Data Program including periodic "blanket" counts to supplement the continuous count (reference) stations. An update of the traffic counts was conducted in 2004. GRSM has seven portable counters that can be moved around to count traffic on an as-needed basis. Permanent count equipment is located on the following roads:

- Abrams Creek;
- Balsam Mountain Spur Road (northbound only);
- Heintooga-Round Bottom (northbound entrance lane);
- Big Creek Camping Access Road;
- Cataloochee Campground Road Eastbound Exit Lane;
- Cosby Campground Northbound Exit Lane;
- Foothills Parkway (west section) from US 129 Northbound Access Lane;
- Bryson City-Fontana Road Entrance;
- Greenbrier Ranger Station Southbound Entrance Lane;
- Cherokee Orchard Road Northbound Lane;
- Foothills Parkway (west section) from Tennessee Look Rock Southbound Access Lane;
- Twentymile Area;
- Rich Mountain Road;
- Parson Branch Road;
- Cades Cove Loop Road; and
- Deep Creek Camping Area.

C. Emergency Response

GRSM law enforcement rangers are generally first to arrive at an accident location. They typically respond to a 911 call, direct contact, or a direct call to GRSM. If the 911 call is coming from a cell phone, it is picked up by the nearest tower in an abutting county. Cell phone coverage within the park is spotty. Once it is received by a county 911 system, the county notifies GRSM communications. For a 911 land line call, it is routed to the county in which it originates, and then GRSM is notified. As first responders the rangers are able to respond to the majority of emergency incidents without calling for assistance from outside the park. Exceptions include major emergencies in which additional equipment, expertise or manpower is required. Usually when such an emergency occurs, GRSM calls upon the City of Gatlinburg or City of Cherokee. Life Star is available for emergency transportation from the park to University of Tennessee Hospital in Knoxville when the incident location is accessible to helicopter transport. Many of the Stakeholders said during the first Stakeholder meeting that all emergency response and law enforcement agencies in GRSM, North Carolina, and Tennessee corporate and communicate well with each other.

D. Existing Transit

Gatlinburg and Pigeon Forge have two of the more successful transit systems in the state of Tennessee. Sevierville added transit service in 2004, and it is operated by the City of Pigeon Forge. Financial assistance for the Gatlinburg, Pigeon Forge, and Sevierville transit systems is provided by the Tennessee Department of Transportation's Public Transportation, Waterways, & Rail Division. The specific office within that division is called the Office of Public Transportation (OPT).

The Gatlinburg trolley system began in May 1980, and has served over 17 million people in its 23-year life through 2002. It has 6 trolley routes that cover 10.35 square miles**. Table 1** presents a summary of the Gatlinburg routes, 2006 ridership, headways, and peak season vehicle usage.

TABLE 1. GATLINBURG MASS TRANSIT SUMMARY

ROUTE	2006 RIDERSHIP		HEADWAYS	PEAK SEASON
	Number	Percent	(Minutes)	VEHICLES
Welcome Center (Purple)	326,513	37.0	15	3
National Park (Brown)	8,825	1.0	90	1
Dollywood (Pink)	150,020	17.0	60	1
City Hall (Blue)	132,370	15.0	15	2
Uptown Loop (Red)	247,091	28.0	15	2
Arts and Crafts Community (Yellow)	17,649	2.0	30	2
TOTAL	882,468	100.0	N/A	11

Gatlinburg operates one trolley route within the park that runs from June through October from the Gatlinburg Mass Transit Center (downtown Gatlinburg) to the Laurel Falls parking area and the Elkmont Campground via Newfound Gap and Little River roads. It also makes a stop at the Sugarlands Visitor Center. The summer roundtrip is approximately 90 minutes with a roundtrip fare of $2.00. **Figure 5** shows the 2006 route map.

The Pigeon Forge Fun Time trolley system began in June 1986 and has served millions of people in its life. **Table 2** presents a summary of the routes, 2006 ridership, headways, and peak season vehicle usage. It has 16 trolley routes that cover an area of about 10 square miles as shown in **Figure 6**.

FIGURE 5. TROLLEY ROUTES IN GATLINBURG, TN

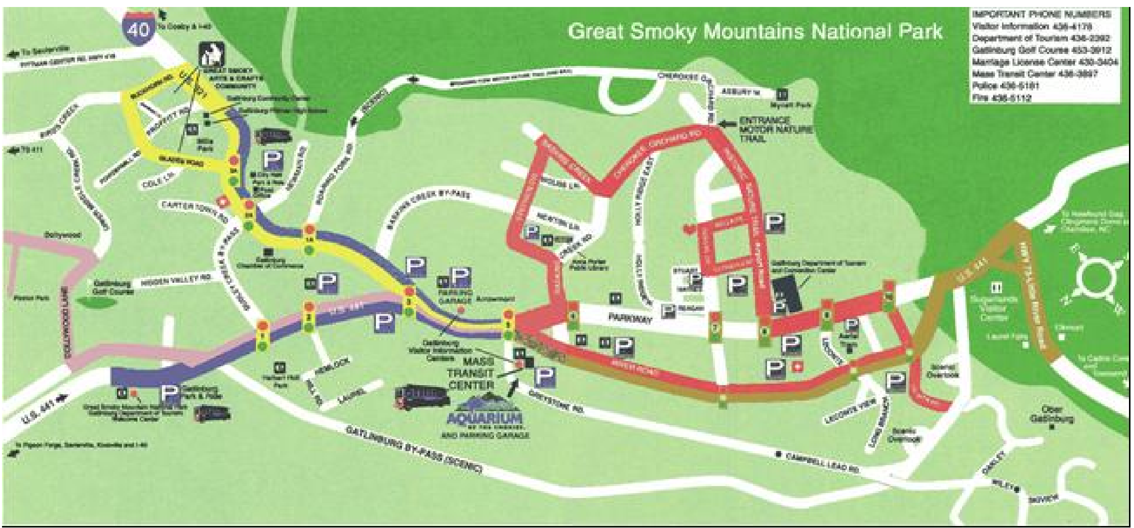


TABLE 2. PIGEON FORGE/SEVIERVILLE MASS TRANSIT SUMMARY

ROUTE	2006 RIDERSHIP Number	2006 RIDERSHIP Percent	HEADWAYS (Minutes)	PEAK SEASON VEHICLES
North Parkway	179,232	28.0	20	6
South Parkway	70,193	11.0	20	2
Court House	40,404	6.3	30	3
Wears Valley	18,478	2.9	40	1
Gatlinburg Welcome Center	43,545	6.8	30	1
Dollywood	208,633	32.6	20	2
Dolly's Splash Country	27,696	4.3	15	1
TOTAL	588,181	100.0	N/A	16

Pigeon Forge also operates one trolley route between Patriot Park and the Gatlinburg Welcome Center. The frequency of service is every 25 to 30 minutes at a cost of $0.75. The cost of all other routes is $0.50.

FIGURE 6. TROLLEY ROUTE IN PIGEON FORGE/SEVIERVILLE, TN

E. Agency Collaboration

In the early 1990s the Sevier County Transportation Board was formed to coordinate and promote transportation needs in the county. It is comprised of the city managers of the four gateway communities in Sevier County (Sevierville, Pigeon Forge, Gatlinburg, and Pittman Center), the county mayor, and a representative of GRSM. The board meets monthly. The board offers an ideal mechanism for communication and cooperation between GRSM and the Sevier County gateway communities. Sevier County has been making significant headway towards addressing their transportation deficiencies.

There is not a similar formal line of communication between the park and communities in Blount County, TN; however, the park has representation on the Tuckaleechee Cove Advisory Board (TCAB) that includes the gateway communities of Townsend and Tuckaleechee Cove. TCAB provides a forum for discussing transportation issues of mutual concern and interest. Most recently the park worked closely with both Townsend and Tuckaleechee Cove on the *Gateway Communities Transportation Strategies Plan.*

On the North Carolina side, there is a less structured line of communication between the park and gateway communities. While transportation and visitation are shared concerns, the volume of tourist traffic through the North Carolina gateway communities, except for Cherokee, is less significant than on the Tennessee side of the park. Steps are being taken to build a working relationship between GRSM and Cherokee, North Carolina. At the first Stakeholder meeting, one North Carolina stakeholder indicated that communication between GRSM and neighboring gateway communities in North Carolina and among the gateway communities themselves could be improved. Likewise, a Tennessee gateway community representative said that better communication among planning organizations within the Tennessee gateway organizations was needed.

Other gateway community and regional organizations that provide a means to communicate with GRSM include:

- Partnership for the Future of Swain County;
- Land to Sky Regional Council;
- Great Smoky Mountains Regional Greenway Committee;
- East Tennessee Clean Fuels Coalition;
- Knoxville TPO, and;
- Gatlinburg Gateway Foundation.

II. CURRENT AND ANTICIPATED GRSM PROBLEMS AND ISSUES

Current and anticipated problems and issues are divided into those related to GRSM and those related to the gateway communities and region, though this section is limited to problems and issues pertaining to GRSM. Some problems and issues overlap between the two categories.

Many of today's transportation challenges are not new but have been facing GRSM for many years. In 1982, the GRSM General Management Plan addressed these issues with a section entitled: "Viewing the Park by Motor Vehicle". That section of the report included these key recommendations:

- Design transportation facilities to ensure protection of park resources;
- Expand visitor information services to disperse visitors to less congested areas of park and regional road system;
- Attempt to spread private auto use more uniformly throughout each day and throughout the year;
- Consider restricting the number of vehicles entering the park if traffic congestion significantly degrades from the visitor experience; and,
- Consider a public transportation system

There have been numerous studies conducted to address some of the more pressing transportation issues in GRSM. Ongoing planning studies have addressed and are addressing Cades Cove, North Shore Road, and Elkmont. Moreover, in the recent past, air quality and visitor experience studies have been conducted. GRSM also participated in a regional alternative mode study that included analysis of the Foothills Parkway.

A. Traffic Operations- Level of Visitor Experience

As per the NPS Park Road Standards, "The purpose of park roads remains in sharp contrast to that of the Federal and State highway system. Park roads are not intended to provide fast and convenient transportation; they are intended to enhance the visitor experience while providing safe and efficient accommodations of park visitors and to serve essential management access needs. They are not, therefore, intended nor designed as continuations of the State and Federal-aid network. Nor should they be designed or designated to serve as connecting links to those systems. And within parks, no roads or other circulation system should be planned or designed merely as a device to link points of interest."

Although not its primary purpose, the GRSM road system provides regional transportation mobility. Even though US 441 is administratively discontinuous through the park, the road directly links the cities of Gatlinburg, TN and Cherokee, NC. Most visitors and local residents are unaware that US 441 becomes Newfound Gap Road at the park boundary. Most published road maps do not show the change in the roadway's name or function within park boundaries. Similarly, the Spur between Pigeon Forge and Gatlinburg is the most direct link between these two cities. To a lesser extent, Little River Road links Gatlinburg with Townsend and other cities in Blount County.

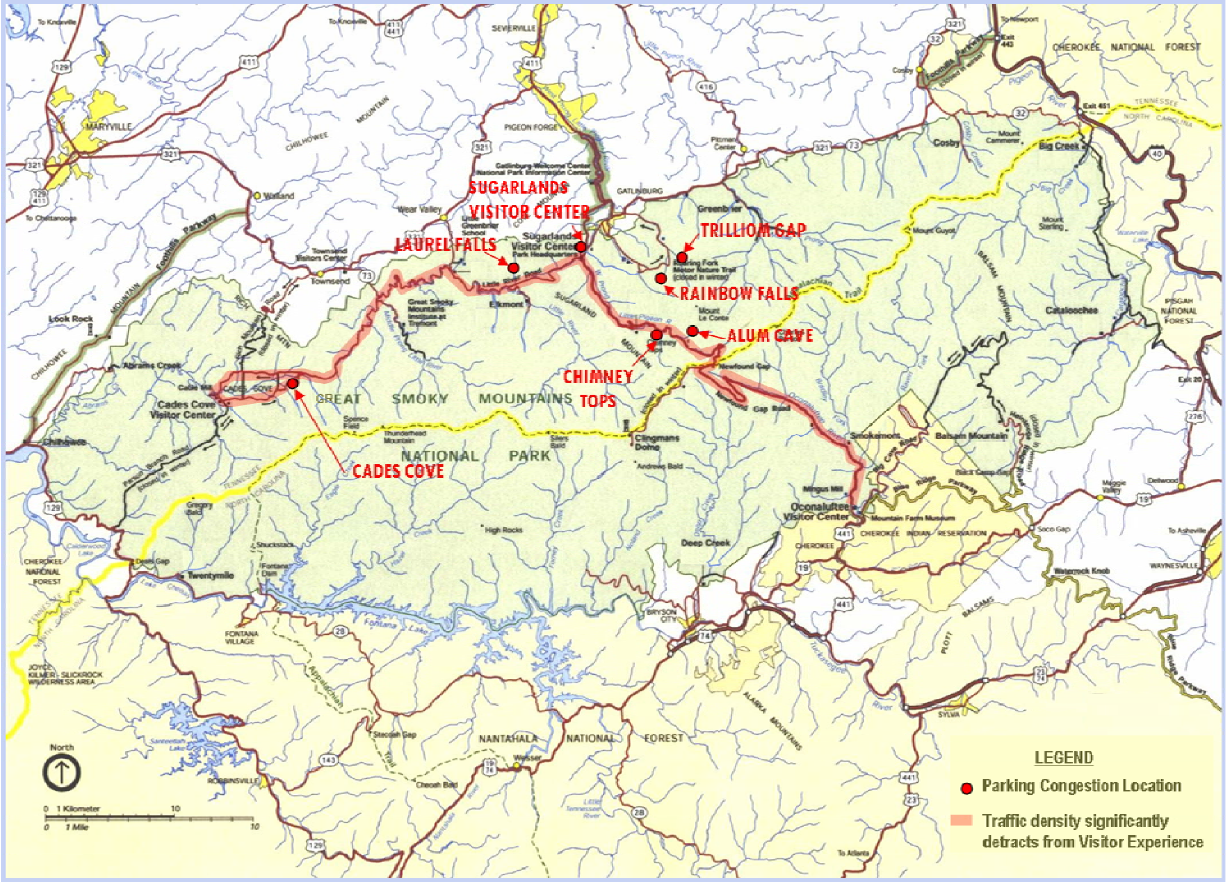
Traffic engineers typically quantify two-lane roadway operating conditions using a quality of service (Level of Service) concept that is published in the *Highway Capacity Manual* (HCM2000, Transportation Research Board Special Report 209). Two-lane highway Level of Service is defined by two criteria: average travel speed and percent of time spent following other vehicles. For roads within GRSM however, this evaluation process is not entirely valid. First, the HCM's evaluation procedure is applicable for higher design speed roads. Second, and more importantly, the criteria used in the HCM evaluate motorists' mobility, for which travel time is a major consideration.

Travel time and inability to pass slower vehicles need not be the only evaluation criterion for roads within national parks. Instead, the criteria may need to be based on roadway density, or the percent of the road occupied by vehicles at a given moment. More than likely, the densities that result in a poor Level of Service using HCM criteria will far exceed the density at which a significant detraction from the visitor experience occurs.

At what density does traffic volume begin to detract from the visitor experience? A 2002 study for the Foothills Parkway concluded that 10 to 15 cars in a two-way, half-mile roadway segment seemed reasonable, or 20 to 30 cars per mile. The *Visitors Survey Study Completion Report (*Dec., 2002 by the NPS for the Blue Ridge Parkway) reported a user preference for no more than 21 vehicles per mile. Using a mid-range value of 25 cars per mile results in a corresponding volume of approximately 4,500 vehicles per day (vpd), assuming 12 percent peak hour traffic, a 50/50 directional distribution and an average travel speed of 25 – 30 MPH. Cades Cove Loop Road, being a destination, is one-lane and one way, consequently, its capacity may not be related to a density of 10 to 15 vehicles per half mile. Expectation and capacity for this road needs to be further refined. It's important to note, however, that within park road system, there are various functional classifications: Public Use Roads (four classes: Principal Road/Parkway, Connector Road, Special Purpose Road, Primitive Road), Administrative Roads (Administrative Access Road, Restricted Road), Urban Parkways, and City Streets. Therefore, quantitative depiction of critical density levels is for discussion purposes only.

As shown in **Figure 4**, Little River Road, Laurel Creek Road, the Cades Cove Loop Road, and Newfound Gap Road all experience traffic volumes that would significantly detract from the visitor experience. Newfound Gap Road, between the Sugarlands Visitor Center and the North Carolina State line carries roughly 8,500 vpd on summer weekdays and probably experiences traffic densities over 25 vehicles in a half-mile section. Little River Road, with daily summer traffic volumes ranging from 4,100 to 5,100 VPD experiences peak period densities of approximately 10 to 15 vehicles per half-mile section.

FIGURE 7. PARKING AND TRAFFIC CONGESTION IN GRSM



B. Congested Parking Facilities

According to GRSM personnel, several trail head parking facilities experience peak period parking congestion including (see Figure 7):

- Alum Cave;
- Chimney Tops;
- Laurel Falls;
- Rainbow Falls; and.
- Trillium Gap.

Accomplishing the perfect balance between providing sufficient visitor parking at attractions and protecting the resources that the visitor has come to experience is extremely difficult. Overbuilding to accommodate the maximum number is not sustainable, resulting in unused parking much of the year and a greater impact to resources. Limiting parking at trailheads and attractions, while contributing to congestion within the park, helps manage the number of visitors at any one location to a level that protects resources and provides a quality visitor experience. Limiting the size of parking areas, however, does result in overflow parking (during peak season), and resource damage can occur as a result of overflow parking. The extent of resource damage can be controlled through measures such as bollards, fencing and boulders as well as strategies such as congestion monitoring and traffic control.

Furthermore, the Sugarlands Visitor Center parking lot can become congested during peak periods, but the average duration is short, thereby creating frequent turnover. GRSM stakeholders have reported that parking facilities in Cades Cove often approach or exceed their capacity.

C. Road Safety

GRSM is in the top 15 national parks in terms of the number of vehicle accidents, which is a disturbing statistic that should be changed if possible. There are 250 to 300 motor vehicle accidents on GRSM roads every year, which is an average of nearly one every day. On Newfound Gap Road, 90 accidents were recorded in Year 2000, which is an average of about one every 4 days. Despite only 4,100 to 5,100 vpd on Little River Road, it produces about one accident every 8 to 9 days.

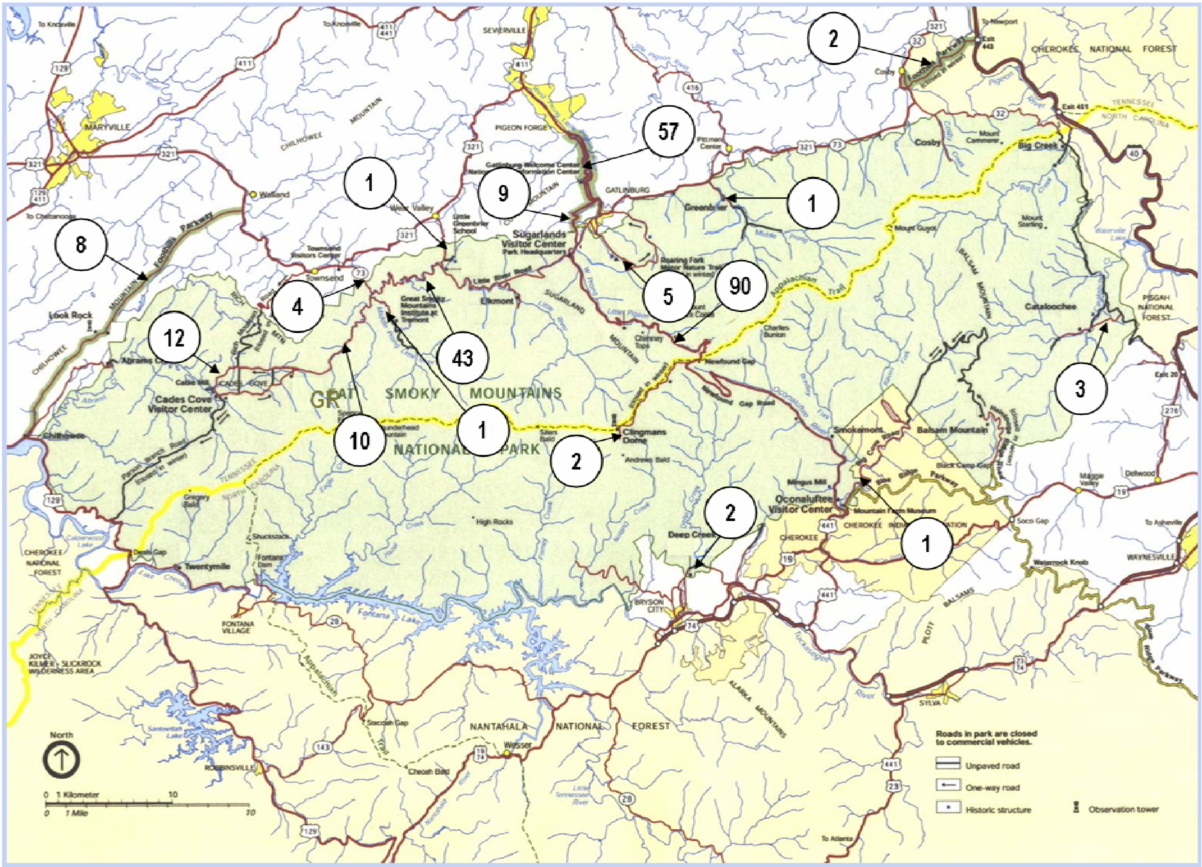
The total number of accidents occurring on GRSM roads is a significant concern to park management and staff. The accidents reported include car crashes and those involving road crew workers who are mowing and making repairs in traffic situations.

GRSM roads are heavily traveled, and for the most part, are winding roads and/or have limited forgiving aspects such as full shoulders. Further contributing to the accident potential on GRSM roads is the environment, in terms of both weather and animals. All of these are factors that require the driver to take appropriate care when traveling through the park. However, the type and characteristics of the roads are not the only contributing factor to automobile accidents. Many times, driver errors such as speeding, inattentiveness, or unfamiliarity with the area contribute to vehicle accidents.

The dual function of many GRSM roads and the vehicle mix contribute to automobile accidents. Some motorists using the roads are simply traveling to their destination as a commuter and have no interest in enjoying the park. Other motorists are traveling on GRSM roads purely for enjoyment of the park. Having two types of motorists on GRSM roads increases the potential for accidents. Likewise, there is a varied mix of vehicles using GRSM roads. Commercial vehicles are not allowed, but motor homes and tour buses with lengths of up to 40 feet are. Smaller vehicles such as motorcycles, scooters, and bicycles, as well as pedestrians, also use park roads.

Traffic Accidents by Road – Traffic accidents by road have been recorded, and Year 2000 data are summarized in **Figure 8**. More accidents occur on Newfound Gap Road (90 in 31.5 miles) than on any other GRSM road. This road accommodates more traffic than any other park road except the Spur. The Spur experienced 57 accidents in Year 2000 followed by Little River Road with 43 accidents. Ten accidents occurred on Laurel Creek Road and 12 on the Cades Cove Loop Road.

FIGURE 8. YEAR 2000 MOTOR VEHICLE ACCIDENTS



Accident Trend – Since 1995, annual motor vehicle accidents are typically in the 250 to 300 range with the exception of 1997, when 343 accidents were reported**.** **Figure 9** depicts a plot of annual accidents by district and by the total. In 1997, I-40 was closed for much of the summer, diverting traffic to Newfound Gap Road. Many accidents are caused by poor weather conditions such as snow and fog; therefore the yearly variations may be partially due to severe winters or above-average rainfall and fog. GRSM's North District has responsibility for the Spur, Newfound Gap Road within Tennessee, the Gatlinburg By-Pass, and Little River Road from the Sugarlands Visitor Center to the Sinks. The remaining portion of Little River Road is in the Cades Cove District. The South District has responsibility for Newfound Gap Road in North Carolina.

Traffic Violations- One strategy GRSM uses to reduce the number of accidents is enforcement of traffic laws. The park issues tickets to violators operating vehicles unsafely, exceeding the speed limit, and commercial vehicles cited for entering the park without the appropriate permits. Year 2001 and 2002 traffic violations by region (most prevalent infractions) are provided in **Table 3**. In Year 2002, 730 speeding tickets were issued which is 200 more than were issued in 2001. Unsafe operation accounted for 139 tickets in 2001 and 116 in 2002. In 2002, 82 tickets were issued for commercial vehicle violations

FIGURE 9. ANNUAL ACCIDENTS BY REGION

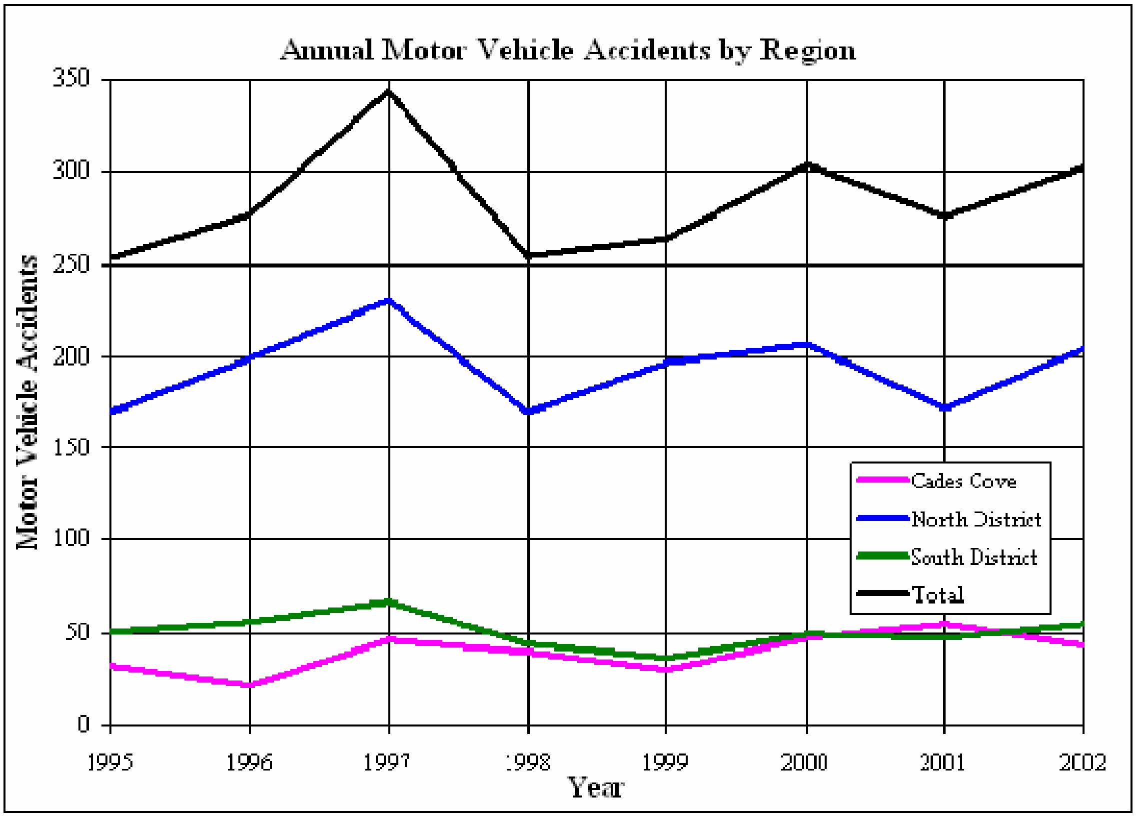


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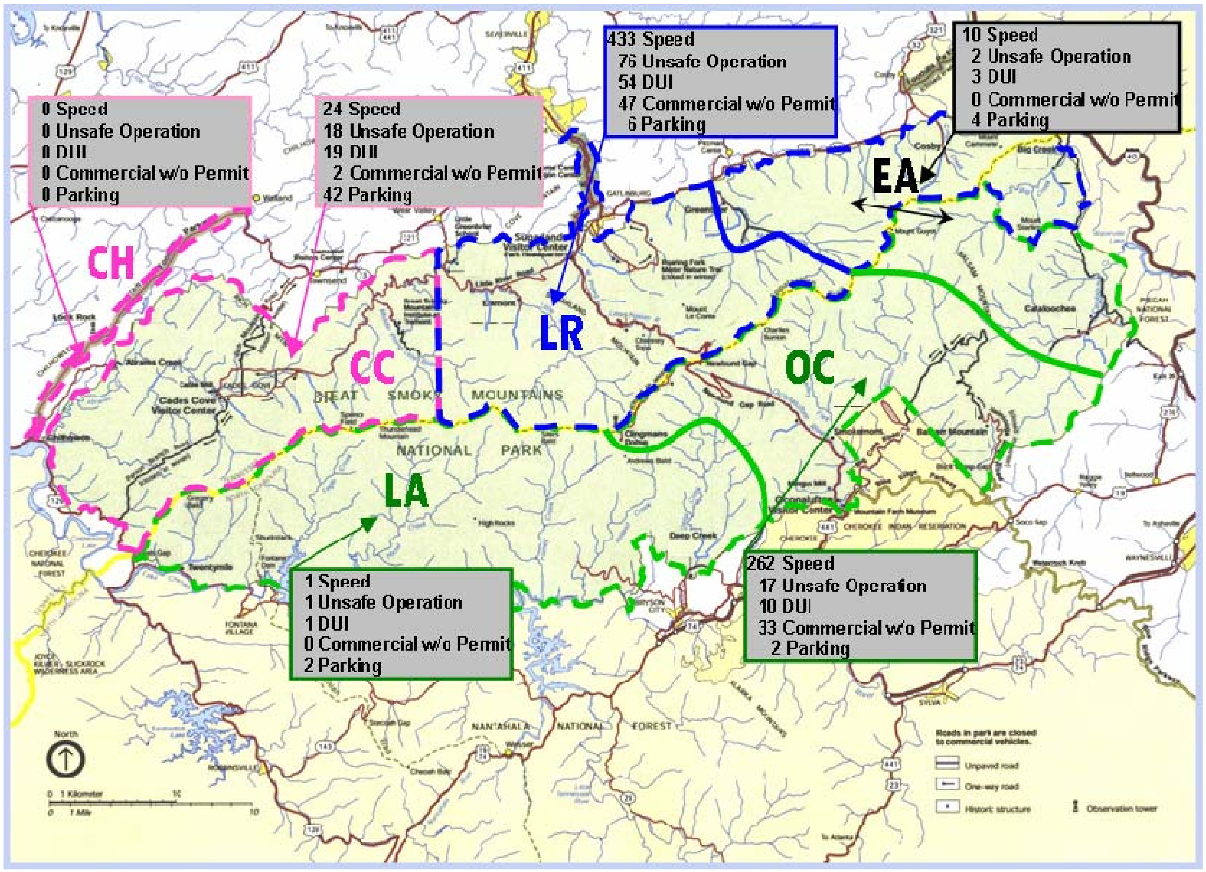
TABLE 3. VIOLATIONS BY REGION

VIOLATIONS	Cades Cove		North District		South District		Total	
	2001	2002	2001	2002	2001	2002	2001	2002
SPEED	10	24	312	443	200	263	522	730
UNSAFE OPERATION	15	18	98	80	26	18	139	116
DUI	26	19	48	58	16	11	90	88
COMMERCIAL W/O PERMIT	3	2	30	47	17	33	50	82
PARKING	27	42	2	10	3	4	32	56

The violations have been grouped by the location of the offense within the park. Prior to 1999, GRSM divided the park into six districts including Cades Cove (CC), Chilhowee (CH), East (EA), Little River (LR), Oconaluftee (OC) and Lake (LA). Today those six districts have since been combined into three districts. The Cades Cove District consists of the western Foothills Parkway along with the area north of the state line and west of the Sevier County line. The North District is the area east of the Blount County line and north of the state line. The South District is the park area located in North Carolina. The 2002 traffic violations issued as categorized by the old districts are shown in **Figure 10**.

FIGURE 10. 2002 VIOLATIONS BY REGION



D. Dissemination of Information

Many GRSM staff and stakeholders have indicated that the dissemination of information to visitors needs to be improved. For example, during a past flood that caused Little River Road to be closed, there was confusion on which roads were closed and the recommended detour route. Moreover, when the road was finally opened, many GRSM employees learned about the opening from a press release. In a Visitor Experience Stakeholder Break-out meeting, the group consensus was that all seasonal employees and visitor center volunteers need training on park activities. Most visitors do not plan their trip in advance, but rely on park employees to tell them what activities to participate in based on their interest. The most frequently asked question is how long does it take to drive to our GRSM destination? Some stakeholders suggested that combined training for gateway community visitor centers and park employees might be explored.

E. Cades Cove Traffic Congestion

Cades Cove attracts as many as 2 million visitors per year and would rank in the top 10 among US national parks if it were a park itself. It is comprised of pastoral fields, a collection of historic buildings, scenic mountain and valley views, and an abundance of wildlife. Due to high levels of visitation, park facilities and resources are being impacted to the extent that the quality of the visitor experience is compromised. With such high visitation, navigating the 11-mile one way loop road during peak periods is often problematic taking 3 to 4 hours. Most visitors travel the Loop Road by automobile, while others hike, bike or experience the Cove on horseback. In 2002, the park, in an effort to address congestion and response to public input, installed two directional signs along Cades Cove Loop Road notifying motorists of the opportunity to exit the Loop Road via Sparks and Hyatt Lanes. Currently there are no daytime access restrictions except the prohibition of motorized vehicles on Wednesday and Saturday mornings until 10:00 a.m. (May through September). On these mornings the Loop Road is open to bicycles and pedestrians only.

In an effort to preserve and protect Cades Cove, the National Park Service, in partnership with Knoxville Regional Transportation Planning Organization (TPO), is working on a development concept and transportation management plan (Commonly known as Cades Cove Planning). When completed, the Plan will provide a comprehensive, long-range approach to managing the Cove's natural and cultural resources and improving the quality of the visitor experience. Five alternatives (one no action and four action) were developed during Phase I and are being revised and more fully developed in Phase II. The four transportation action alternatives range are a low impact alternative of improving pull out and parking; peak season reservations; voluntary transit with peak season reservations, and; peak season mandatory transit.

All of the action alternatives include ITS enhancements to enable the park to communicate more effectively with its visitors. The first phase of the study is complete. It is anticipated that Phase II will be complete in the spring of 2008.

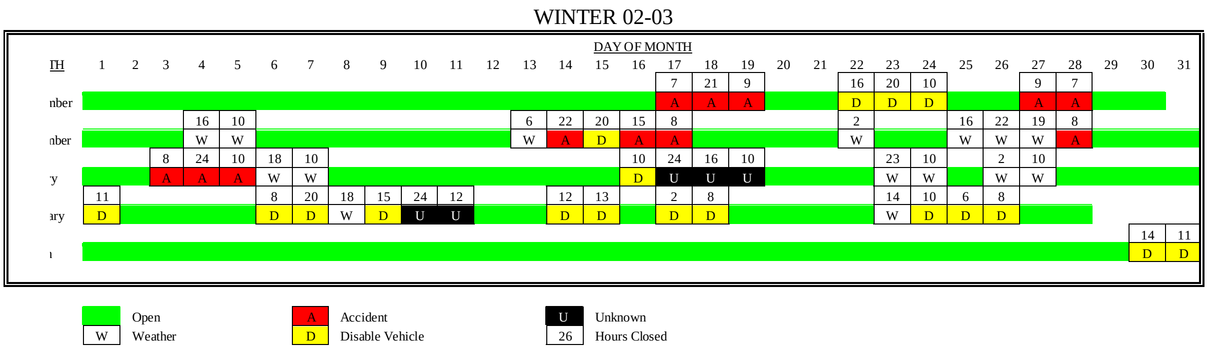
F. Newfound Gap Road Closures

During the winter months of November through March, Newfound Gap Road is closed to traffic for short periods of time because of snow and ice on its surface. Road closures are necessary to allow park staff to clear and sand the roadway, protect visitors from unsafe driving conditions, and prevent motor vehicle accidents. GRSM has road condition evaluation criteria that are used to determine if the road is to be open, and if so, does there need to be any restrictions placed on it? The following criteria are used:

- Level 1- Open, no restriction, watch for fog;
- Level 2- Open, no restriction, but watch for ice and snow;
- Level 3- Open, but restricted to 4-wheel drive or "tire chains";
- Level 4- Closed except for "tire chains" vehicles; and,
- Level 5- Completely closed.

Figure 11 shows the number of unplanned road closures during the winter of Years 2002-2003. Even though some of the road closures were attributed to accidents or disabled vehicles, most of them were weather related. If it is recorded as being closed because of weather, the chief ranger makes the decision to close the road based on surface conditions before an accident occurrs. The closure and open hours reflect a Level 5 condition (complete closure) changing to a Level 2 condition (open to all vehicles).

FIGURE 11. NEWFOUND GAP ROAD CLOSURES



In the winter of 2002-2003, the road was closed for approximately 645 hours, or 18 percent of the total hours available. It was closed for portions of 49 days, which is 32 percent of the 151 total days in that 5-month period. In February, the worst month for road closures, it was closed just over one-fourth of the time.

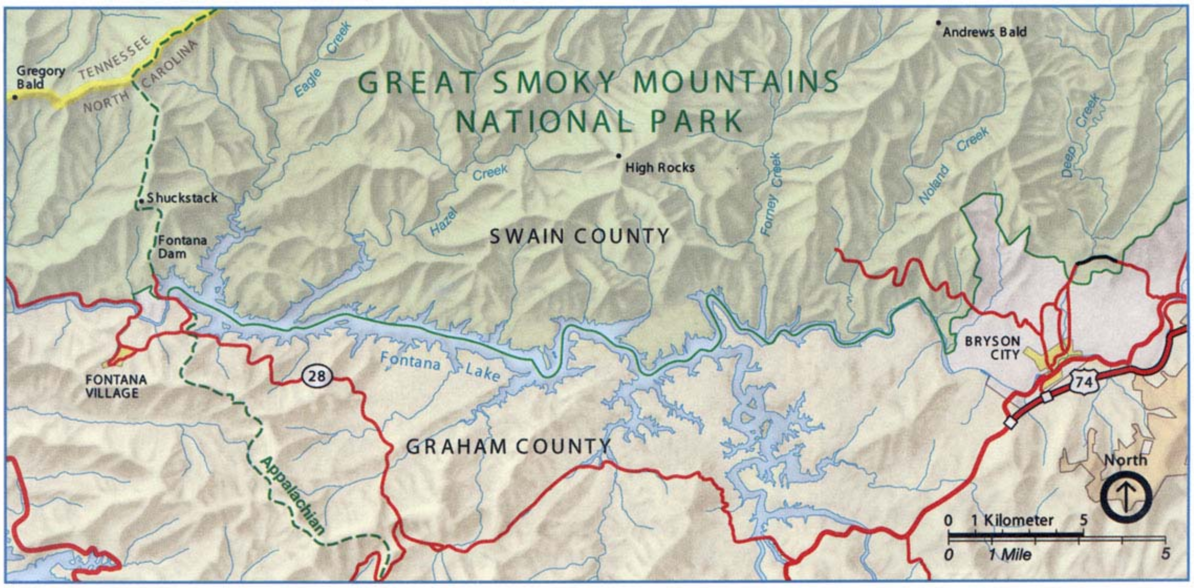
ITS and advanced technology could play a significant role in detecting poor pavement conditions on Newfound Gap Road, disseminating this information to GRSM personnel, and then providing the motoring public with the appropriate information. With better and more timely information, accidents can be prevented and unnecessary travel can be avoided.

G. Completion of the North Shore Road

In the early 1940s, the Tennessee Valley Authority (TVA) constructed Fontana Dam to provide energy for the Alcoa Aluminum Plant's World War II efforts. Fontana Lake was created by the dam and property to the north of the lake became landlocked because NC 228, the only access to this land, was flooded. Ultimately, this landlocked property became part of GRSM, but as part of that agreement, the Department of Interior agreed to replace NC 228 with a new road along the north shore of Fontana Lake. Seven miles of that road were constructed in the 1960s, but the remaining approximately 23 miles has not. In October 2000, Congress budgeted $16 million of Department of Transportation (DOT) appropriations to resume construction of the North Shore Road in GRSM. Because the road would be constructed on federal land with federal money, the National Environmental Policy Act (NEPA) requires the federal agencies involved in the project, the Federal Highway Administration (FHWA) and the National Park Service (NPS), to prepare an Environmental Impact Statement (EIS). The purpose of the North Shore Road EIS project was to discharge and satisfy any obligations on the part of the United States that presently exist as a result of the 1943 Agreement, between the U.S. Department of the Interior (DOI), Tennessee Valley Authority, Swain County, North Carolina, and the state of North Carolina. **Figure 12** illustrates the project area studied as part of the North Shore Road EIS.

In early October 2007, the NPS and FHWA released the Final Environmental Impact Statement (FEIS) for the North Shore Road (complete FEIS available at http://www.northshoreroad.info). The NPS preferred alternative is a recommendation that a monetary settlement be provided to Swain County in lieu of constructing 29 to 34 miles of new road through GRSM. If it is not completed, advanced technology could be used to better manage traffic or alternate routes.

FIGURE 12. NORTH SHORE ROAD EIS PROJECT AREA



H. Completion of the Foothills Parkway

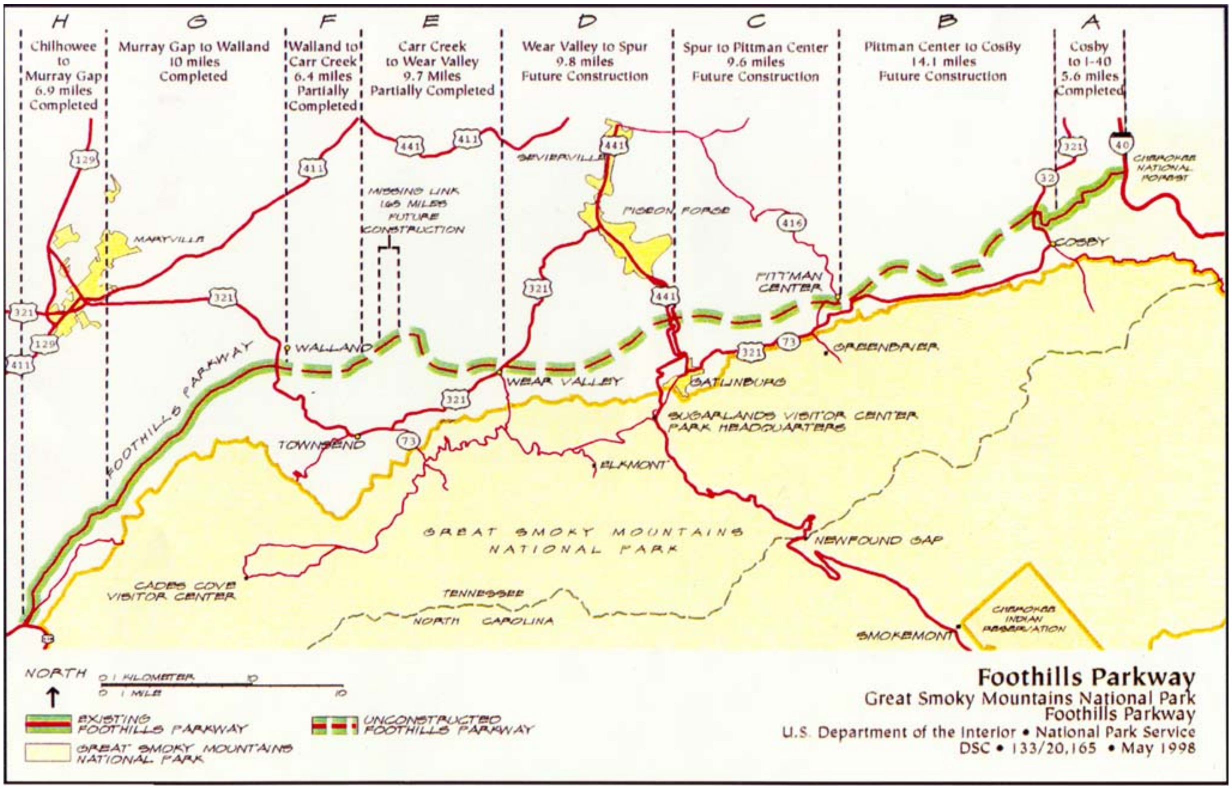
The Foothills Parkway is a partially completed limited access road with a 72-mile corridor that is on the northern flank of GRSM and extends from I-40 in Cocke County to US 129 in Blount County. A feasibility study examined all or portions of this road, which when completed, would provide scenic views of GRSM and other recreational opportunities. As a secondary benefit, the Foothills Parkway is expected to help relieve traffic congestion in and around GRSM. Today, only two discontinuous sections, one on the east end and two on the west end, are completed. **Figure 13** shows the completed and un-constructed sections of the Foothills Parkway.

The Foothills Parkway would intersect a proposed Bus Rapid Transit (BRT, see Section III.-B.) corridor at the US 441 "Spur" between Pigeon Forge and Gatlinburg. In fact, the Spur is within GRSM and was constructed to be part of the Foothills Parkway facility.

The study concluded that the Foothills Parkway could be completed and still achieve all of its original goals. All sections offer opportunities to view GRSM and the surrounding foothill areas, and consequently, have the potential to provide a pleasant driving experience. Moreover, a completed Parkway will also provide improved connections to the regional roadway network and will reduce traffic on several existing roadway sections within and outside the park. Conversely, its completion may introduce traffic congestion around interchanges and intersecting arterials.

One concern about completing the Foothills Parkway is that it may carry too much traffic, which would then detract from the visitor experience. ITS may provide a solution to this concern. Traffic flow could be monitored on the road and when undesirable densities are reached, demand could be limited. Motorist could be warned of restrictions via variable message signs and other means.

FIGURE 13. SECTIONS OF THE FOOTHILLS PARKWAY



I. Elkmont Preservation

Elkmont is located off of Little River Road and offers a variety of cultural, natural, and recreational experiences and opportunities. The Elkmont enclave itself began in the early 1900s and the park acquired all of the buildings in 1934. Originally it was a logging community and later it was transformed into a summer resort with membership coming from affluent Knoxville families.

In the 1982 GRSM General Management Plan, it was recommended that all buildings in Elkmont be removed and the area returned to a natural condition. However, in 1994, Elkmont was listed as a Historic District and 67 of the 86 structures were placed on the Natural Register of Historic Places, making GRSM rethink its 1982 position. As such, GRSM retained a consulting firm in 2001 to conduct an Environmental Assessment (EA), which was to be completed in summer 2003. Increased controversy and the complexities of the area revealed during the EA process have led park officials to now conduct an EIS instead. The outcome of the EIS is expected by 2008.

As GRSM struggles with the long term plan for Elkmont, it should consider how ITS can help manage traffic flow oriented to this area whether it is restored to its natural environment, retained in its current configuration, or changed to something between these two extremes. Moreover, ITS could also assist in enhancing the visitor experience in this exceptional section of the park.

J. Air Quality

GRSM issued a briefing statement in December 2001, that included the split photographs shown above of Gregory Bald from Look Rock Observation Tower. Natural visibility of approximately 113 miles, shown on the left occurs less than one percent of the time. Conversely, the average visibility, which is shown on the right, is 25 miles and occurs 40 to 60 percent of the time. In the summer conditions are worse because the average visibility should be 77 miles but is only 15 miles.

Based on the 1977 Clean Air Act Amendments, the Great Smoky Mountains National Park and other national parks exceeding 6,000 acres in size, were granted a Class I classification worthy of the greatest degree of air protection under the Act. The Clean Air Act allows the National Park Service to work with EPA, states and local regulatory programs to prevent air pollution at GRSM from worsening.

In 1992, the Southern Appalachian Mountains Initiative (SAMI) was established as a voluntary, multi-organizational group to develop recommendations for improving air quality in the Southern Appalachians. In August 2002, SAMI published its Final Report on air quality with the following visibility recommendations:

- To improve visibility, it is most important to reduce sulfur dioxide emissions;
- To improve visibility, it could become necessary, under certain future dioxide control strategies, to reduce ammonia emissions.
- For SAMI to accomplish its mission, emissions reductions are essential both inside and outside the region.

Other conclusions pertaining to acid deposition and ozone exposure were also presented in the final report. SAMI's recommendations to mitigate the region's poor air quality included air-pollution legislation, a reduction in ammonia emissions from animal feeding operations, and conservation practices.

These EAC's which are included in the respective state implementation plans for Tennessee and North Carolina require early action plans that include all necessary elements of a comprehensive air quality plan, but are tailored to local needs, county by county, and driven by local counties. As long as the Compact terms and milestones are met, the effective date of nonattainment designation is deferred along with related requirements. Full attainment must be reached and documented by 2007 to retain "attainment" status.

At the national level, EPA has revised the National Air Quality Standards to require 8-hour rather than 1-hour compliance for maximum ozone emissions. The effect of this change was to cause the Knoxville, Tennessee area including Blount, Sevier and Cocke Counties or the Tennessee side of the Great Smoky Mountains National Park to be designated as potential nonattainment areas. Under a December 2002, agreement, EPA, the State of Tennessee and the affected counties entered into an Early Action Compact (EAC) for the express purpose of commitment to EPA's "Protocol for Early Action Compacts Designed to Achieve and Maintain the 8-Hour Ozone Standard."

Similarly, on the North Carolina side of the park, the Mountain Area

Compact (EAC) which includes the western mountain areas of North Carolina (Counties of Buncombe, Henderson, Haywood, Madison and Transylvania) was established to take control measures necessary to obtain the 8-hour ozone standards. These counties have acknowledged the importance of implementing these standards in promoting quality of life and future healthy development and to avoid the negative implications of nonattainment in the mountain regions of North Carolina.

Federal land managers have responsibility to protect the air quality and related values in natural parks and wilderness areas. State and federal regulatory agencies find themselves balancing the need to protect Class I-areas with the need to accommodate growing economies in the Southeast.

K. Other Environmental and Preservation Issues and Concerns

Besides air quality, GRSM has other environmental and preservation issues. According to the stakeholders these concerns include:

- The introduction of non-native exotic species
- Dead trees resulting from insects and poor air quality
- River and creek pollution which leads to the reduction or elimination of some species (some of the water pollution is caused by poor air quality)
- Noise pollution from motorcycles and campsite generators, though noise pollution has no demonstrated long term effect on animals and wildlife

III. REGIONAL TRANSPORTATION PROBLEMS AND ISSUES

Over 20 years ago, traffic in GRSM gateway communities was almost all destined to GRSM. One exception was Gatlinburg, TN, which attracted some traffic exclusively destined to that city, though much of that traffic became a secondary trip to GRSM. Today, however, many of the tourist trips to the region never visit GRSM, or do so as a secondary trip. This is especially true in Gatlinburg, Pigeon Forge, and Sevierville, and less so in Townsend, Cosby, and many of the gateway communities in North Carolina. Therefore, there remains a relationship between traffic congestion in the gateway communities and GRSM, but it is not as strong as in past years.

A. Traffic Congestion in Gateway Communities

Because of many factors (including the regional road network, the population distribution, and the development of the local tourist industry), the most significant gateway community traffic congestion occurs in Sevier County, TN. In the Regional Partnership Stakeholder Break-out meeting, the members agreed that traffic congestion in the gateway communities was the top issue and that all other issues are a result of this problem. By far the most congested corridor is the major north-south route bisecting the county, which consists of SR 66, US 441, and US 321. This corridor, which extends from I-40 on the north end of the county to GRSM on the south end, is commonly called the Smoky Mountain Parkway. As a result of congestion on the Smoky Mountain Parkway, Middle Creek Road became over-capacity, and was widened as a result. All of the east-west US routes leading into the cities of Sevierville, Pigeon Forge, and Gatlinburg also experience traffic congestion.

The City of Cherokee, NC experiences traffic congestion on US 441 during peak tourist seasons, and as a result, has commissioned a traffic study to be conducted by a transportation engineering consulting firm. This study should be available spring 2008.

In Townsend, TN near Cades Cove, traffic congestion is increasing, in part because tourist-related development is on the rise. Recently, the Tennessee Department of Transportation widened a section of US 321 in response to additional traffic on the roadway.

Though traffic congestion in many gateway communities still occurs, it has been mitigated to some extent by more road capacity. However, while gateway communities have taken measures to add roadway capacity over the past 30 years, GRSM has not. Consequently, some roads that lead up to GRSM and connect with GRSM roads have been improved, but the continuation of the road improvements in GRSM has not. This phenomenon is problematic to GRSM in that increased traffic is generated, but park roads are not capable of accommodating it.

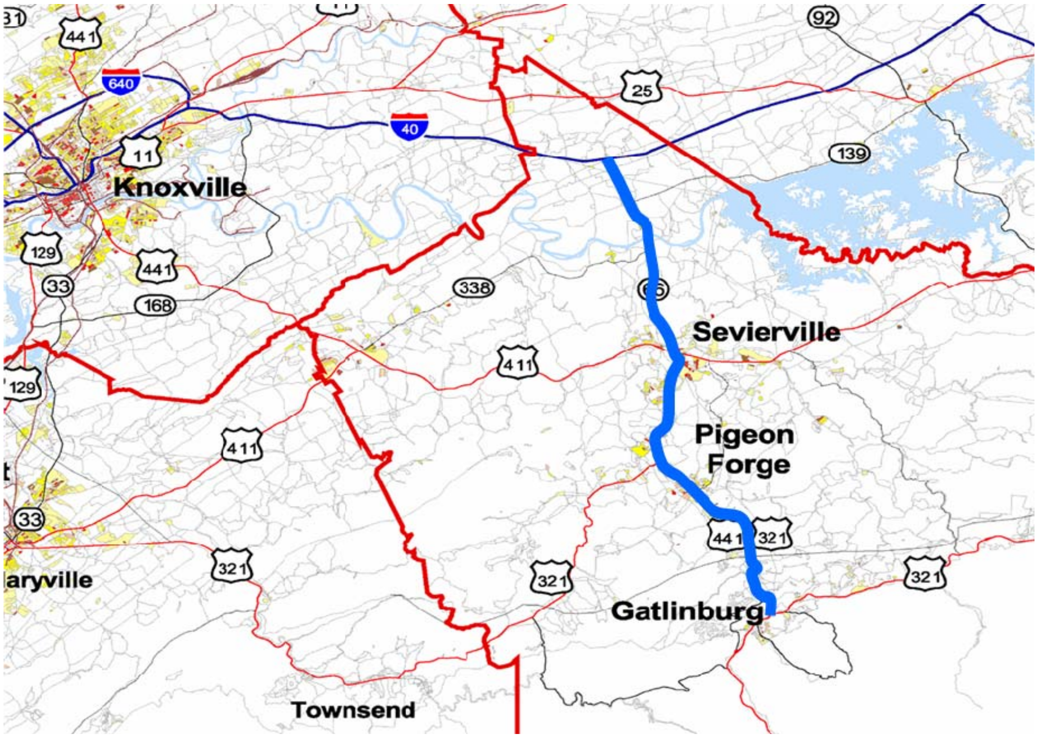
B. Improved Transit- BRT Corridor

In 1996 a planning group was organized to explore the possibility of taking a regional approach to transportation planning that would address the environmental, economic and logistical concerns of the communities in East Tennessee. That effort ultimately resulted in the formation of the Regional Transportation Alternatives Committee. That committee, in turn, called for a regional transportation alternatives plan to be formulated that took into consideration Knox County, all counties abutting Knox County plus one additional county: Cocke County.

The result of the *Regional Transportation Alternatives Study* was a conceptual regional transit framework that centered on five counties: Knox, Blount, Sevier, Anderson, and Loudon. In short, the study concluded that there is not sufficient activity today or in the foreseeable future to support a rail-based concept. Instead, the study recommended that major regional activity centers such as Knoxville and Oak Ridge be linked with an express bus service.

A Sevier County Bus Rapid Transit (BRT) study was the next logical step to be taken after conducting the *Regional Transportation Alternatives Study* in 2001 and 2002. The BRT study was conducted by Wilbur Smith Associates for the Knoxville Transportation Planning Organization with the purpose of analyzing regional transit options in East Tennessee. **Figure 14** illustrates the proposed route.

FIGURE 14. PROPOSED BRT CORRIDOR



In addition to express bus service, the study recommended Bus Rapid Transit (BRT) in the "Sevier County Corridor." The study indicated that all key factors that make transit successful are in place in this corridor: concentration of activity, disincentives for auto use, and a positive attitude towards transit as illustrated by current trolley ridership in Gatlinburg and Pigeon Forge. The report goes on to say that what is needed is an additional competitive edge for the trolleys, and that edge can be provided with BRT.

Coordination between this strategic deployment plan for GRSM and the BRT feasibility study can be achieved through the Sevier County Transportation Board, of which GRSM is a member. The client for the BRT planning study was that Board.

C. I-40 Rock Slides

I-40, between Asheville, NC and Newport, TN traverses some of the most severe terrain in the region. There are three tunnels and most of the remaining roadway is located on major cut or fill sections. Historically, this section of road has experienced a significant number of rock slides, some so severe that I-40 had to be closed. The NCDOT has established I-40 rock slide alternative routes as follows:

- Motorists in the immediate Asheville area are encouraged to use US 23/I-26 between Asheville, NC and Johnson City, TN.
- Motorists traveling westbound on I-40, east of Statesville, NC and I-77, are encouraged to use I-77 to I-81.
- Motorists traveling westbound on I-40, east of Greensboro, NC who are destined to Chattanooga, TN are encouraged to use I-85 to Atlanta, GA, then I-75 to Chattanooga, TN.

Although the US 23/I-26 corridor offers a good alternative for motorists in the immediate vicinity of Asheville, US 441 and Newfound Gap Road is another viable alternative for motorist forced to detour off of I-40 due to a rock slide. As a matter of fact, the NCDOT publishes a document that illustrates alternate routes, and this map includes US 441 and Newfound Gap Road. For motorists traveling between Knoxville and Asheville, US 441 and Newfound Gap Road may be the quickest route.

The implementation of ITS in and around GRSM would facilitate and support the I-40 rock slide plan that is currently in place. One of the biggest concerns expressed by GRSM officials is that an alternate route plan convey the park's commercial vehicle restriction.

D. Better Lines of Communication

The park recognizes the importance of working with the gateway communities both in North Carolina and Tennessee. Hence, they have established working relationships with many groups including Partnership for the Future of Swain County, Tuckaleechee Cove Advisory Board, Knoxville TPO, TVA, Sevier County Transportation Board, Gatlinburg Gateway Foundation, Leadership Blount County, and Leadership Sevier County. However, communication between GRSM and some North Carolina organizations and gateway communities needs to be enhanced, according to some of the stakeholders. Generally speaking, many stakeholders believe that better cooperation and collaboration exist between GRSM and organizations in Tennessee.

Not only did some North Carolina gateway community leaders mention the need for better communication between them and GRSM, but they also indicated that better communication among themselves is needed. In addition to better communication, these stakeholders said that better cooperation was needed. Some said that a lack of cooperation between North Carolina gateway communities was detrimental to the area's economic viability and quality of life.

E. Better Guide Signs

A NCDOT Steering Committee member suggested that GRSM wayfinding needs to be improved. The main North Carolina portal into GRSM is at Oconaluftee, at Newfound Gap Road (US 441), but other entrances exist on the south border including Lakeview Drive, North Shore Road, Big Cove Road, and Heintooga Ridge Road. The static guide signs in North Carolina confuse many visitors because they do not provide specific information on park destinations and are too general. Tourists often arrive at the Newfound Gap Road entrance when they wanted to go elsewhere.

Though not specifically identified in any Stakeholder meetings, wayfinding signs on the Tennessee side of the park should also be examined. Consequently, it is recommended that all wayfinding signs in North Carolina and Tennessee be analyzed.

IV. ITS THEMES

The GRSM and regional transportation issues, combined with project aims from other National Park ITS projects, were reviewed in consideration of goals and policies identified in the GRSM General Management Plan and GRSM planning documents, particularly information gathered from an initial GRSM ITS exploration performed at GRSM in 2000 by Brudis & Associates, Inc. to support mitigation associated with the rehabilitation of the Newfound Gap Road. This study united Stakeholders from GRSM, TDOT, FHWA-TN, NC DOT, FHWA-NC, the Tennessee and North Carolina gateway agencies including Cherokee, and assocated Chambers of Commerce. This study also performed interviews with 18 randomly selected businesses. With the aid of the

GRSM Stakeholders, the list of issues was refined into the following guiding ITS themes for GRSM:

- Improve Operations and Safety
- Enhance Visitor Experience
- Regional Partnerships
- Preservation.

These themes allow the park to define the areas of ITS they would like to emphasize as they relate to broader concerns. Themes for this study were used as a guide for all project activities, to ensure a common focus as work progressed. Examples noted under each theme area were primarily offered for discussion purposes.

The national parks were established with this purpose: "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (National Park Service Organic Act, August 25, 1916). Given this purpose, balancing the preservation theme with other themes is paramount. ITS is one tool to use in addressing how to leave park resources unimpaired for the enjoyment of future generations.

A. ITS THEME: Improve Operations and Safety

The first theme identified is to improve transportation operations and safety in the GRSM. As is widely reflected in many forums, traffic congestion in the national parks can be as vast as the parks themselves. Both safety and mobility are the focus of this theme. There are many approaches that may address this theme, including: encouraging the use of alternative travel modes, providing real-time travel condition information both pre-trip and en route, addressing accident "hot spots", enhancing incident management resources, and employing a reservation system regulating the amount of vehicles coming into the park. Quantifiable means that may be used to measure the effectiveness of strategies employed include: vehicles, number of trips, number of accidents, and travel speeds.

Other parks in the National Park System have approached improvements to transportation operations and safety with ITS applications. Examples include deploying an enhanced communications system, deploying temporary/interim advanced warning systems in maintenance areas and work zones, deploying a real-time traffic information system in the gateway communities, and providing enhanced non-auto access to the park.

B. ITS THEME: Enhance Visitor Experience

Visitors to any recreational area typically have some travel characteristics in common: they do not seek the most "efficient" transportation route, prefer using their vehicle to get around, do not have local knowledge on how to best find local traffic and weather information when they need it, are likely to be unaccustomed to the local transportation network, use a multiple occupancy vehicle, spend more money per vehicle miles traveled (when at their destination) than do commuters; and have specific ideas as to how their vacation "should" be. These travel characteristics have been conveyed in visitor use surveys. It is important to note that enhancing the visitor experience within the park is different from enhancing a tourism experience, and that park visitation must be context-sensitive. The tourism experience by contrast includes the visitor's experience, but also includes enhancing the tourism industry's revenues. With an enhanced tourism experience, the gateway communities benefit along with the visitors to the park.

Many things that enhance a visitor's experience also enhance overall tourism. However, the visitor experience can be difficult to enhance as each visitor's expectations differ. Measures of effectiveness for determining the impacts of ITS tools on enhancing the visitor experience include congestion measures such as delay, modal shifts to transit, number of vehicle trips in the park, length of visit, visitation numbers, and use of traveler information services available (such as websites hits and number of phone calls). Barriers to deploying ITS technologies to enhance visitor experiences include limited communications capabilities within the park, institutional issues and limited power availability.

Traffic that obstructs business access, trolley service, and emergency services as a direct result of park traffic should be minimized. Also, travelers arriving in the area who realize that travel conditions in the park are not optimal (weather, congestion, full parking) may alter their plans to make the most of their stay in the area, including other ways to experience the park (bike, hike, use available transit). These examples reduce excessive vehicular travel and minimize environmental impacts, this improving the park visit.

This theme focuses on a range of transportation issues, including effective marketing of the system, to enhance the visitor experience.

C. ITS THEME: Regional Partnership

This theme focuses on what needs to be in place for the other themes to occur, and what needs to be in place for recommendations from this study to be effectively implemented. The previous theme addressing the visitor's experience (and, as applicable, the tourism experience) provides a financial incentive to partner and cooperate with this study and resulting follow-on projects. Also, transportation providers (agencies and organizations that own, operate, or maintain any roadway, bridge, tunnel, or that provides transportation services) in the gateway communities will benefit from successful partnerships for the good of the region. Advanced technologies, as a stand-alone strategy, are not able to enhance regional partnerships. The focus of the potential application of advanced technologies within this project is to address transportation issues/need. Collaborative activities that foster regional attendance and agreement, such as this project, are the primary means of enhancing regional cooperation. The biggest barrier to regional partnerships is the very thing that creates this need – the institutional issues that exist and the associated communications walls between agencies.

D. ITS THEME: Preservation

Examples of transportation projects that have been implemented in other national parks toward preserving park resources include improving transportation safety, traffic operations and parking management. Balancing the preservation theme with an enhanced visitor experience plus other themes is paramount. Measures of effectiveness for preservation include environmental measures (e.g., air quality measures, water quality measures, and plant and animal life health), congestion measures, number of vehicle trips, transit ridership, and overall park visitation. Barriers include institutional practices, visual impacts of field equipment, and enforcement policies.

V. OPPORTUNITIES

Opportunities may be considered as actions that could make the transportation system or agency operations more efficient, safer, or less intrusive, but may not necessarily be associated with a transportation issue or problem. Opportunities may also be considered as situations that may be leveraged to maximize investments made on the transportation system.

The primary opportunity is one that must be present in order to consider deployment of ITS in restrictive economic conditions. That opportunity is that ITS must be considered as one means of addressing one or more regional transportation issues. It is clear that ITS and advanced technologies can be utilized to address current GRSM transportation issues and problems. Through ITS and new technologies, traffic operations can be improved, resulting in a better visitor experience, among other benefits that may be derived from deployment of ITS technologies.

Additional factors to consider when deciding whether to move forward with ITS in the GRSM include:

- Employ "lessons learned" and experience from other national parks (e.g., Acadia, Gateway, Glacier, Yosemite).
- Employ experience/best practices from related areas (e.g., rural ITS deployments, rural emergency response, road-weather maintenance programs, area special events).
- Maximize SAFETEA-LU potential for supporting transportation operations improvements,
- Leverage FHWA Office of Operations activities, http://ops.fhwa.dot.gov/program_areas/programareas.htm.
- ITS in GRSM potentially may assist NPS in coming up with congestion metrics for visitor experience.
- Pursue potential NPS model ITS deployment, e.g., the existing GRSM dynamic message signs
- Leverage enthusiasm for regional activities related to ITS as a result of this project's activities.

A. Regional Opportunities

Regional opportunities will be utilized to aid in selection of appropriate ITS Strategies. Several regional opportunities have been identified and they include, in no particular order:

The **Cades Cove alternatives analysis** study that is underway is exploring various ITS features. That study should build upon this GRSM ITS Plan with regard to ITS strategies. The alternatives analysis is due for completion by winter 2008.

Gatlinburg Transit has received a grant to add an **Automatic Vehicle Location** (AVL) system to the current fleet of Gatlinburg Trolleys. The AVL system is closely tied to a "next bus" system that will provide an estimated time of arrival at each trolley stop, and these enhancements are also anticipated within the next 5 years. An opportunity exists for other area transit providers to procure necessary equipment at the same time that Gatlinburg Transit procures their equipment. This will maximize an opportunity for economies of scale. The cost to obtain necessary equipment will not be lower if obtained separately.

Sevierville is now providing trolley service. Through an agreement between the two cities, Pigeon Forge operates the **Sevierville Trolley** system. Again, regional consideration for expansion may be considered with Sevierville's expansion to achieve economies of scale. Also, it is worth considering purchasing trolleys with ITS technologies already installed.

The **BRT Corridor study** explored Bus Rapid Transit in Sevier County, Tennessee. The proposed corridor would extend via SR 66 and US 441 from I-40 on the north tip of the county down to or through Gatlinburg to the park entrance. If a BRT system is implemented in Sevier County, there would be an opportunity to tie it to GRSM ITS initiatives.

In the **Foothills Parkway Analysis** Final Report, the possibility of limiting demand on the road to preserve an acceptable level of visitor experience is discussed. No specific strategies were evaluated. While the timeframe to construct sections of the Foothills Parkway is unknown, when sections are nearing the bid letting, it would be advantageous to include appropriate ITS technologies and backbone components in the bid package. This is the case for all upcoming roadway (and private developer) improvements. Improvements could include base ITS add-ons such as fiber optic and other utility conduit, located below ground with minimal surface disruption.

Leverage Tennessee ITS Activities – The Knoxville Regional Freeway Management System included a fiber optics communication backbone, variable message signs, closed circuit television system, data/traffic collection, and weather stations. In addition, TDOT recently deployed a statewide 511/dial-in travel information system. Tennessee activities include transit management systems in many surrounding regions.

Leverage North Carolina ITS Activities – The NCDOT ITS architecture for the region surrounding the park includes provision of tourist and traveler information that may include weather and accident response information. Truck safety is also an important factor in NCDOT's ITS architecture. The NC 511 has been implemented. Variable message signs have been added to I-40 between the Tennessee state line and Ashville, primarily to address rock slides. NCDOT also has a roving Incident Management Assistance Patrol.

B. Existing Agreements

Another set of opportunities exist with respect to agreements already in place among the various entities in and around GRSM. Such agreements can facilitate the implementation of many ITS projects, since the projects are typically multi-jurisdictional/multi-user in nature. Following is a summary of such existing agreements that may be helpful.

Since the commencement of this study, GRSM has an established agreement with **NC DOT** for a traveler information **511** service. NCDOT has recognized the value of National Park content by providing menu options with links to the park and also to the Blue Ridge Parkway.

The National Park Service, Department of the Interior and, the Federal Highway Administration, Department of Transportation established an **interagency agreement** in 1983 addressing park roads and parkways. This interagency agreement addresses, in part, planning, design, construction, maintenance, and funding of park roads and parkways.

The park has established agreements on the use of **existing towers** outside the park for the park radio system. These include agreements with the Eastern Band Cherokee Indians (EBCI); Gatlinburg, Graham County, and the US Forest Service.

There are **law enforcement** agreements that spell out jurisdictional issues – the ones in place are with Haywood County, NC, Swain County, NC, Blount County, TN, Sevier County, TN, Cocke County, TN, Gatlinburg TN, and Pigeon Forge, TN. A draft agreement is being worked out with EBCI. As a result of congressional limitations, the law enforcement agreements are such that GRSM can accept a great deal of assistance, but GRSM is not always able to respond in kind.

Law Enforcement also has an agreement with the USDA Forest Service and North Carolina Division of Forestry regarding **wildfire** issues.

GRSM has established interagency agreements with the **Tennessee Valley Authority** and **EPA** for air quality work. Part of these agreements addresses funding issues.

Lastly, a special use permit has been established regarding Gatlinburg's placement of **flood monitoring stations** within the park boundaries.

VI. ITS PLAN OBJECTIVES

A. Relevance to National ITS Goals

Following identification of the GRSM and regional transportation issues in light of the four ITS Themes, a clearer definition of what ITS could accomplish was required. To this end, the project team reviewed the National ITS Program Plan (2002 revision of the 1995 version), developed by FHWA and ITS America. The Program Plan identifies a series of ITS "benefit areas" along with associated goals, all of which are at least partially relevant to the GRSM and regional transportation Themes and related issues presented previously. The national goals as written do not reflect the unique aspects of national park activities or of the region as a whole. **Table 4** relates the GRSM ITS Themes to the National ITS Program Plan benefit areas and goals.

TABLE 4. GRSM ITS THEMES IN RELATION TO THE NATIONAL ITS PROGRAM PLAN

NATIONAL ITS BENEFIT AREA	RELATED NATIONAL GOAL	Corresponding GRSM Theme	Corresponding GRSM and Regional Transportation Issue
Safety	Reduce annual transportation -related fatalities by 15% overall by 2011, saving 5,000-7,000 lives per year.	• Improve Operations and Safety	**Inside GRSM** • Safety/Traffic Accidents
Security	A transportation system that is well - protected against attacks and responds effectively to natural and manmade threats and disasters, enabling the continued movement of people and goods even in times of crisis.	• Preservation • Regional Partnership for Transportation Operations and ITS Development	**Inside GRSM** • Other Environmental / Preservation Concerns **GRSM Region** • I-40 Rock Slides • Newfound Gap Road Closures • Better Lines of Communication Needed
Efficiency / Economy	Save at least $20 billion per year by enhancing throughput and capacity through better information, better system management and the containment of congestion by providing for the efficient end-to-end movement of people and goods, including quick, seamless intermodal transitions.	• Regional Partnership for Transportation Operations and ITS Development • Improve Operations and Safety	**Inside GRSM** • Traffic Operation - Level of Visitor Experience (LOVE) • Congested parking facilities • Cades Cove • Dissemination of Information **GRSM Region** • Traffic Congestion in Gateway Communities • Improved Transit: BRT Corridor • Foothills Parkway • Newfound Gap Road Closures • I-40 Rock Slides • Better Lines of Communication Needed
Mobility / Access	Universally available information that supports seamless, end -to-end travel choices for all users of the transportation system.	• Enhance Visitor Experience • Improve Operations and Safety • Regional Partnership for Transportation Operations and ITS Development	**Inside GRSM** • Traffic Operation - Level of Visitor Experience (LOVE) • Congested parking facilities • Cades Cove • Dissemination of Information **GRSM Region** • Traffic Congestion in Gateway Communities • Improved Transit: BRT Corridor • Foothills Parkway • Newfound Gap Road Closures • I-40 Rock Slides • Better Lines of Communication Needed Better Guide Signs
Energy / Environment	Save a minimum of one billion gallons of gasoline each year and reduce emissions at least in proportion to this fuel saving.	• Enhance Visitor Experience • Preservation	**Inside GRSM** • Air Quality • Other Environmental / Preservation Concerns **GRSM Region** • Traffic Congestion in Gateway Communities

B. ITS Plan Objectives

In order to better reflect the relevant aspects of the ITS goals above as well as the ITS Themes and issues, a series of ITS Plan Objectives have been defined to amplify the ITS Themes. These GRSM ITS Plan Objectives were used to establish the basis for the selection of the ITS Strategies that address GRSM's transportation related issues.

The ITS Plan Objectives, relevant to each of the themes, are as stated below:

Improve Operations and Safety

- Improve traveler information, both static and dynamic
- Improve incident and emergency management services
- Monitor, manage and mitigate congestion
- Improve travel demand management alternatives
- Reduce roadway accidents
- Improve mobility specific to over-crowded parking lots and commercial vehicle operations (CVO) restrictions

Enhance Visitor Experience

- Improve traveler information, both static and dynamic
- Improve incident and emergency management services
- Monitor, manage and mitigate congestion
- Improve travel demand management alternatives
- Reduce roadway accidents
- Improve mobility specific to over-crowded parking lots and CVO restrictions
- Improve air quality

Regional Partnership for Transportation Operations and ITS Development

- Improve interagency / inter-jurisdictional coordination, cooperation and information sharing

Preservation

- Improve air quality
- Monitor, manage and mitigate congestion
- Improve travel demand management alternatives
- Improve mobility specific to over-crowded parking lots and CVO restrictions
- Improve incident and emergency management services
- Reduce roadway accidents

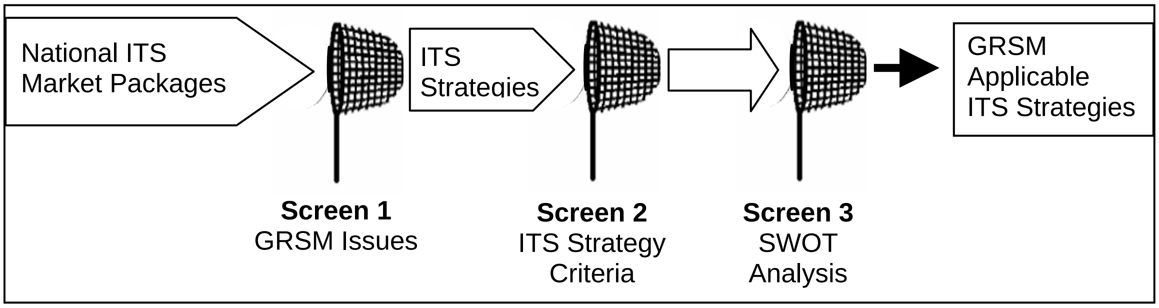
Criteria to select from the list of ITS technologies were developed based on these ITS Plan Objectives.

Section C: Recommended ITS Strategies

I. ITS STRATEGY EVALUATION PROCESS

This section describes the process that was used to develop ITS Strategies for the GRSM ITS Strategic Plan. The process identified and evaluated ITS Strategies in a three-step screening process as shown in **Figure 15**, ITS Strategy Evaluation Process. ITS Strategies that pass the screening process will support the themes and issues identified for GRSM.

FIGURE 15. ITS STRATEGY EVALUATION PROCESS



The screening process provides rationale to evaluate, select and prioritize ITS Strategies for GRSM. The aim is to ensure that ITS Strategies selected for consideration are appropriate and applicable to the issues identified in Section B and that they have the highest potential to be implemented in the GRSM region. The three-step screening process consists of an issue evaluation, a GRSM criteria screen, and a **SWOT** (Strengths, Weaknesses, Opportunities, and Threats) analysis. .

The **first screen** began with candidate ITS Market Packages and any additional technology or equipment grouping that the base list of Market Packages did not include, but was necessary to address all the GRSM project issues.

An **ITS Market Package** is a breakdown of an ITS service that is tailored to meet real world transportation issues. Market Packages do not imply a particular technology, instead are composed of subsystems that contain equipment packages (the physical devices), with interfaces permitting information flow links between the subsystems. The National ITS Architecture defines 85 Market Packages in the following categories: Archived Data Management (AD), Public Transportation (APTS), Traveler Information (ATIS), Traffic Management (ATMS), Vehicle Safety (AVSS), Commercial Vehicle Operations (CVO), Emergency Management (EM), and Maintenance and Construction Management. Information (MC) on the Market Packages, as identified by the National ITS Architecture Version 5, can be found on the National ITS Architecture website: http://www.iteris.com/itsarch.

In the **first** screen, the Market Packages were compared to the issues identified in Section B to determine which Market Packages address the identified issues. Additional definition and research was completed to develop and define appropriate ITS Strategies customized to GRSM needs and applicable to each individual Market Package. These strategies were used in each subsequent screen in the evaluation and prioritization process.

The **second screen** considered the ITS Strategies against criteria developed from ITS Objectives identified in Section B. The criteria screen involved a weight factor applied to each of the criteria. Each weight was established based on Stakeholder input. This screen filtered the ITS Strategies, and provided an initial ranking, to move forward in the screening process.

The **third evaluation** was identified as the most important for this project. The SWOT analysis began by identifying the unique features of the GRSM project region. The SWOT were developed based on information received from Stakeholder involvement, the ITS Workshop, and materials received. At this step in the evaluation process, each ITS Strategy was categorized as part of an initial ITS plan, an expanded ITS plan, or a full ITS plan. The analysis examined the potential for each ITS Strategy to be implemented successfully in the region, based on the region's SWOT.

II. FIRST ITS SCREEN RESULTS

The strategies associated with the full list of Market Packages, as identified by the National ITS Architecture, were explored for the potential of addressing the identified GRSM Issues/Problems. The strategies under review were customized to the circumstances of GRSM, and associated with the Market Packages that apply to the park. Several strategies pertained to more than one Market Package, so the last step was to compile a list of all candidate strategies. This list is presented in **Table 5** in alphabetical order.

TABLE 5. ITS STRATEGIES FOR CONSIDERATION

- Advanced parking management system
- Advanced traveler information system (ATIS) (data manipulation and packaging)
- Air quality alert/advisory system
- Air Quality Data Collection Equipment (GRSM)
- ATIS Dissemination Device – 511/IVR (Interactive Voice Response telephony system)
- ATIS Dissemination Device – Broadcast radio
- ATIS Dissemination Device – FM Subcarrier
- ATIS Dissemination Device – Highway advisory radio
- ATIS Dissemination Device – Internet/web (existing sites, new)
- ATIS Dissemination Device – In-vehicle traveler information services
- ATIS Dissemination Device – PDA (Personal Digital Assistants)
- ATIS Dissemination Device – Traveler kiosks
- Automated gate systems
- Automated Incident / Emergency Management System (includes Park wide Emergency Management system)
- Automated incident detection system (IDS) (Develop incident detection algorithms using collected data.)
- Automatic treatment system
- Automatic vehicle location (AVL) system on Park vehicles
- Automatic warning sign system
- Central information database/ clearinghouse (supports ATMS, ATIS, IMS, IDS, EMS, etc.)
- Closed circuit television camera systems (CCTV) (fixed and/or portable)
- Computer aided dispatch (CAD) systems for transit routing, driver assignments.
- Data interfaces among participating organizations operations centers (GRSM, NCDOT, TDOT, Transit providers, parking, gateway communities, emergency providers. Includes signal timing)
- Detour/alternate route plan development
- GRSM Disaster Response and Recovery Plan
- Dynamic message signs (portable and permanent)
- Electronic communication of hazardous materials cargo to incident response teams
- Emergency operations information clearinghouse
- Incident / Emergency Management Plans
- "Next Bus"-type system (Estimated wait time algorithm)
- Operational strategy development (MOA, MOU, etc. to address ATMS, EMS, IMS, Transit, etc.)
- Operations center software (GRSM, traffic signal, emergency providers, transit) (Adapt gateway community signal timing in response to freeway incidents)
- Optimization software (Snow and regular maintenance activity)
- Park access reservation system
- Park wide Emergency Alert System (EAS)
- Parking security systems (CCTV, audio detection system, vehicular count system, personal communications mechanism for each lot)
- Personalized traveler information services (data manipulation and packaging, fee/back office software. Privately operated)
- Real-time transit traveler / itinerary planning system
- Region wide maintenance and construction information provision
- Road/Weather Information System (GRSM only and region-wide)
- Roadway service patrols
- Safe Zone/Work Zone systems
- Speed advisory system (portable or permanent)
- Traffic detection (speed, occupancy, probe)
- Transit AVL (Advanced communication and vehicle tracking technologies to schedule and route buses) (Request and gather costs to provide AVL and "Next Bus"-type technology for all other transit services into and around the park)
- Transit signal priority in gateway communities
- Transit traveler / itinerary planning systems
- Variable speed limit system

III. SECOND ITS SCREEN RESULTS

The second screen compared the ITS Strategies in Table 5 to criteria developed for the GRSM region. The results of this process were a suggested prioritization for the strategies as well as elimination of some strategies that were deemed unsuitable at this time after further exploration.

The composition of the criteria is from information gathered from Stakeholder and Steering Committee involvement, including the two-day **ITS Strategies Workshop**, and is presented in **Table 6**. (See Appendix A for the highlights of this Workshop). Each criterion, with input from the stakeholders, was assigned a weight. Many stakeholders commented on the Performance criterion, though no performance requirements were identified. It was decided that the Performance criterion would not be used, since all strategies recommended were those proven to perform in other locations. At this stage of the selection process, the "Technology Proven" criterion was deemed a more appropriate gauge. For the GRSM region and as projects near deployment, performance requirements will be determined, agreed to, and utilized to further refine the proposed strategy.

TABLE 6. PROPOSED CRITERIA AND WEIGHTS

Proposed Criteria	Assigned Weight
Performance (will the Strategy meet necessary performance requirements – not yet defined)	N/A
Consistency with themes	5
Degree to which objectives are addressed	5
Implementation cost	3
Operating and maintenance costs	2
Cost effectiveness (B/C ratio)	4
Likelihood of public acceptance	3
Operational feasibility (personnel required? Degree of automation)	4
Extent to which the technology is proven	4
Extent to which ITS Strategy enables other functions	2
Extent to which the Strategy builds upon or leverages other efforts	1

The second evaluation process utilized a weighted matrix. Each Strategy was evaluated for each criterion and assigned a score for that criterion. The ranges for the scores were 1 to 3, with 3 being the most favorable condition. The Strategy's total score was determined by multiplying the score by the criterion weight and summing over the criteria.

The total scores of the weighted matrix were then sorted in descending order. This listing allowed for a logical division among the ITS Strategies into "Strong Merit", "Some Merit", and "Consider at a Later Date" categories to consider for further development, as presented in **Table 7**.

TABLE 7. WEIGHTED MATRIX RESULTS

<table>
<tr><th>Strong Merit</th><th>Some Merit</th></tr>
<tr><td>• Operational strategy development
• GRSM Disaster Response and Recovery Plan
• Advanced traveler information system (ATIS)
• Central information database/ clearinghouse
• Incident / Emergency Management Plans
• Detour/alternate route plan development
• Road/Weather Information System (RWIS)
• Region wide maintenance and construction information provision
• Transit AVL
• Computer aided dispatch (CAD) systems for transit.
• Data interfaces among participating organizations operations centers
• Emergency operations information clearinghouse</td><td>• Park wide Emergency Alert System (EAS)
• Automated Incident / Emergency Management System (IMS/EMS)
• Safe Zone/Work Zone systems
• Operation center coordination/software
• Traffic detection
• Highway advisory radio
• Broadcast radio
• Dynamic message signs
• Air quality alert/advisory system
• Advanced parking management system*
• Automated gate systems *
• Automatic treatment system *</td></tr>
<tr><th colspan="2">Consider at a Later Date</th></tr>
<tr><td>• Internet/web
• Automated incident detection system
• Optimization software
• Closed circuit television camera systems
• Automatic vehicle location (AVL) system on Park vehicles
• Automatic warning sign system
• Transit signal priority
• 511 / IVR
• Roadway service patrols
• Speed advisory system
• Park access reservation system
• Transit traveler / itinerary planning systems
• “Next Bus”-type technology
• Traveler kiosks</td><td>• Variable speed limit system
• Personal Digital Assistant (PDA) system
• Parking security systems
• In-vehicle traveler information services
• Personalized traveler information services
• Air Quality Data Collection Equipment
• FM Subcarrier
• Real-time transit traveler / itinerary planning system
• Electronic communication of hazardous materials cargo to incident response teams</td></tr>
</table>

** Additional input was provided by the GRSM staff throughout the development of this project to update park operational changes and the interest in new services. After the Strategies were scored and ranked, it became apparent that these three Strategies, which were initially identified as “Consider at a Later Date”, were desirable to the park for further consideration and hence were elevated to having “Some Merit”.*

IV. THIRD ITS SCREEN RESULTS

Table 7 only represents an objective selection process. The third screen considered more qualitative (rather than quantitative) criteria. One example that highlighted the need for a qualitative screen was that one of the Strategies noted with Strong Merit was a centralized database-type of strategy, but there were not any Strategies listed in this same category that collected real-time data. The third screen compared the Strategies against the strengths, weaknesses, opportunities, and threats unique to the region. The third screen also considered which Strategies may be considered enabling strategies, dependencies and reliabilities among the Strategies, and also captured the park's focus. The Strategies that were in the Strong Merit and Some Merit categories were the ones that progressed into the third screen.

The third evaluation was identified as the most important for this project as the intent was to go beyond conceptual ideas and explicitly bring out issues related to GRSM's political and institutional characteristics. The Strengths, Weaknesses, Opportunities, and Threats (**SWOT**) analysis began by identifying the unique features of the GRSM project region. The SWOT were identified based on information received from Stakeholder involvement, and the ITS Workshop. This analysis essentially examined the potential for each ITS Strategy to be implemented successfully in the region. Areas where further work may be needed (e.g., institutional arrangements) and the potential for benefits are among the results noted in a typical SWOT analysis.

Strengths represent related resources and capabilities of GRSM and its partners to advance certain ITS Strategies as well as sustain those strategies once deployed. Weaknesses represent potential deficiencies and internal barriers that would hinder the ability to initially deploy ITS. Opportunities are the ITS supportive conditions in the greater and surrounding regions that GRSM and its partners could pursue for benefits. Opportunities enhance the ability to initially deploy ITS Strategies. Threats are perceived or actual negative external conditions that may arise as a result of pursuing certain ITS Strategies. Threats weaken the ability to sustain ITS in the future. The following four tables identify the region's strengths (**Table 8**), weaknesses (**Table 9**), opportunities (**Table 10**), and threats (**Table 11**) to deploying ITS.

TABLE 8. GRSM REGION STRENGTHS

STRENGTHS	DETAIL
Desire to work together for the better of the GRSM community	Maximizes ability to do things for the good of the region: • A strong willingness to work together for the good of the community has been evidenced in the project meetings. • Many approaches have been tried to unite the national park and two-state region, and all participants appear to be willing to try new ways or re-try old ways to strengthen the partnership
Maximize the partnership potential evidenced during project meetings and activities	Willingness and desire to work together for the good of a region is paramount to it becoming a reality. Attendance and dialogue in meetings has been very positive. A strong desire for improved working relationships among project participants has been voiced repeatedly.
Recognized transportation problems	This enables the region to move forward as a united front. There is a lack of project participants competing to ensure that one or more "pet projects" have increased priorities. All project participants recognize and agree on the transportation problems that need addressing
City of Gatlinburg issued an automatic vehicle location (AVL) and other transit technology deployment Grant	Provides a current opportunity that may be leveraged for the good of the region. This Strength for the City of Gatlinburg means that several advanced transit technologies may be deployed within the next five years. The City secured a grant to deploy an advanced transit system which is likely to include AVL, "Next Bus", and transit signal priority capabilities. "Next Bus" capabilities determine the estimated time of arrival of the next vehicle to any particular transit stop. The anticipated arrival time is displayed at the transit stop to inform potential riders.
GRSM already trying to integrate ITS elements into planning projects (and trying to obtain funding to support integration)	Demonstrates that GRSM acts in forward-thinking and far-reaching ways. This type of action is conducive to successful ITS programs.

TABLE 8. GRSM REGION STRENGTHS

Alternative/technological transportation solutions, including ITS Strategies, can address many identified transportation issues	This is a necessary component for progressing with a needs-based ITS Program Plan. National Parks have chosen not to address transportation challenges through road building; therefore other tools (e.g., technology) need to be considered, as long as applied in a context sensitive way. If found applicable to the issues, then there are opportunities to use such tools.
Many transportation planning studies underway in the region that contain ITS components.	Potentially provides additional opportunities for ITS to be integrated into regional projects.
Both North Carolina and Tennessee have laid the groundwork for regional ITS architectures.	This is a necessary component for progressing with any ITS deployments (if federal funding is to be considered as one means of the deployment). Provides a current opportunity that may be leveraged for the good of the region.
Strong NPS preservation ethic	The NPS and GRSM are committed to the preservation and protection of resources for the enjoyment, education and inspiration of this and future generations. Preservation is a higher priority (higher than providing transportation services) from a NPS viewpoint. This commitment leads the park to search for solutions to the issues faced in the park today (including congestion). These solutions may include and support ITS.
Park already collects a wide variety of information.	This information can be used to populate necessary data bases. And, since this function already exists, no additional effort or staffing would be necessary to populate necessary databases to support a number of ITS Strategies.

TABLE 9. GRSM REGION WEAKNESSES

WEAKNESSES	**DETAIL**
There is a strong perception that ITS field equipment will be visually disruptive to the Park's natural environment.	This limits the ability to deploy many types of ITS elements. Contributing factors to overcome this weakness include: • Park leadership supports the concept that ITS field equipment does not necessarily have to be visually disruptive to the natural environment • location of ITS field equipment • selection of field equipment/technology • color of field equipment • size of field equipment • lighting of/on field equipment
Communications challenges	ITS technologies will not work if they are unable to communicate reliably and appropriately. • Wireline communications may be an issue within the park given trenching for underground communications or overhead communications would be disruptive to the park environment. • Wireless communications is an issue given sight-lines for point-to-point communications, along with limitations related to cellular phone service within the park. Provision of towers and antennas would be visually disruptive. • Outside the park, telecommunications costs are not as much of a concern, but may be of local concern to those agencies installing specific ITS equipment.
Utility (power supply) challenges	ITS technologies require power to operate. Challenges associated with supplying power throughout the National Park may prohibit deployment of necessary ITS elements for maximum effectiveness of the overall system. Unique to GRSM, the park's natural environmental conditions limit options to traditional power utilities (i.e., there are too many cloudy days to consider using solar power and the park does not want to cut tree limbs to maximize what little potential there is to utilize a solar power system). Conversely, electrical power requires either underground or overhead utilities which may be environmentally disruptive in a National Park.
Difficulty in balancing how needs are addressed in each of the theme areas (visitor experience with preservation with improving operations and safety, etc.)	The priorities for one item often conflict with those for others – e.g., warning signs along roads disrupt the visual experience. Priorities may be difficult to determine between theme areas.

TABLE 9. GRSM REGION WEAKNESSES

WEAKNESSES	**DETAIL**
Inexperience with collaborative operations of ITS.	This is new territory for localities and organizations in the region. There is a natural reluctance to provide the degree of cooperation and collaboration necessary for successful ITS operations when the reality of a deployment/operations is approaching. Issues include: • Concurrence on the types of information (and possibly degrees of control) to be shared among the participating agencies and organizations. • Concurrence on the types of strategies to employ
Costs	Identifying appropriate means of funding is a common challenge across the National Park Service. This challenge has been amplified in the current economic conditions. Identifying and ensuring that capital, operations, and maintenance funds are available is necessary to deploy technologies. The possibility exists to contract with an organization to provide all necessary services (as a means of addressing Staffing needs), but this option requires significant, ongoing funding. Costs to be considered include: • Deployment costs • Operations and maintenance costs • Additional up-front costs to secure/develop field equipment compatible with the park environment.
Uncertainty of where and how to fit ITS funding requests (projects) into the normal NPS PMIS funding process	NPS does not (yet) have an ITS Program. Currently ITS is funded through Technology Programs or ITS must compete for transit funding (Alternative Transportation System Program). Both of these programs funds are limited. In addition, the GRSM National Park (in part or whole) is not considered a part of either state's planning programs/regions.
There is a perception that ITS could harm the local economy and keep people away from visiting the retail areas.	One example is level of traffic congestion: A park visitor may prefer to have unencumbered travel while the gateway communities and their retailers may actually prefer congested roadways because the visitors may get out of the traffic by visiting one or more of the retail establishments. If ITS is implemented, it could hurt the economic viability of area businesses.
Potential difficulty in balancing the needs/goals of the park with the needs/goals of the gateway communities.	There are differences between park and regional visitor experiences to the park and a visitor experience in the region. One example is level of traffic congestion: A park visitor may prefer to have unencumbered travel while the gateway communities and their retailers may actually prefer congested roadways because the visitors may get out of the traffic by visiting one or more of the retail establishments.

TABLE 9. GRSM REGION WEAKNESSES

WEAKNESSES	DETAIL
No recognized "champion" to continue the ITS initiative once this planning project is completed.	Given that the park is not considered in either of the bordering states as inclusive to established regions, nor that the park has a transportation operations within its organizational structure, it is likely to be difficult to move forward in the ITS deployment process without someone to "champion" the effort. A champion is anyone who is adopts the ITS initiative as something very positive for the area and provides extraordinary efforts to keep ITS in the forefront of transportation issues.
Institutional characteristics / Agency organizational structure	GRSM and the area surrounding it are operated by local agencies, whose organizational structures may not have sufficient professional staffing in the area of transportation planning, transportation management and operations. GRSM specifically (and common to NPS units) does not have transportation management operations personnel, with the exception of law enforcement and maintenance personnel.
Traffic management is not a traditional NPS function.	The structure isn't in place to deal with many of the transportation issues. There is an outstanding question of how/where to fit any new roles/responsibilities into an existing structure or how/what new structure is to be implemented to support not only transportation, but also ITS.
Lack of available support staff to maintain and operate ITS	Key to any operational improvement is ensuring that the improvement can be adequately operated. This element includes appropriately trained staff members in addition to staffing levels. Manual and semi-manual system(s) require frequent updates (of real time traffic conditions). In addition, automated systems require appropriately skilled individuals to maintain operations.
Lack of ability to collect information to populate the systems	Information is currently collected by a wide variety of means and is not consistently or completely shared among those involved with tourists and responsible for transportation operations.

TABLE 10. GRSM REGION OPPORTUNITIES

OPPORTUNITY	DETAIL
Leverage Cades Cove Study recommendations/actions	This is a specific opportunity that the region may be able to utilize. The Cades Cove study that is underway is exploring use of DMS and potential reservation and transit system alternatives which could be enhanced by ITS. This project will not duplicate efforts in Cades Cove with regard to ITS strategies, but we will look to build upon that study's findings depending upon when that study is completed.
City of Gatlinburg issued an automatic vehicle location (AVL) and other transit technology deployment Grant	Provides a current opportunity that may be leveraged for the good of the region. The City secured a grant to deploy an advanced transit system which is likely to include AVL, "Next Bus", and transit signal priority capabilities. "Next Bus" capabilities determine the estimated time of arrival of the next vehicle to any particular transit stop. The anticipated arrival time is displayed at the transit stop to inform potential riders.
Maximize Gatlinburg Transit AVL opportunity – aim to impact/influence regional transit operations	This is a specific opportunity that the region may be able to utilize. The City of Gatlinburg has received a grant to add an AVL system to the current fleet of Gatlinburg Trolleys. The AVL system is closely tied to a "next bus" passenger information system that will provide an estimated time of arrival at each trolley stop, and these enhancements are also anticipated within the next 5 years. An opportunity exists for other transit providers to and around the park to explore the opportunity to procure necessary equipment at the same time that Gatlinburg procures their equipment. This will maximize an opportunity to realize economies of scale. The cost to obtain necessary equipment will not be lower if obtained separately.
Maximize Sevierville Trolley establishment (expansion of Pigeon Forge Trolley to provide and operate transit services in Sevierville); incorporate ITS into any capital purchases (if possible)	This is a specific opportunity that the region may be able to utilize. Sevierville is looking forward to providing trolley service in the near future. Through an agreement between the two cities, Pigeon Forge will operate the Sevierville Trolley system. Opportunities in this case may be multi-faceted, in that other regional consideration for expansion may be considered with Sevierville's expansion to obtain economies of scale. Also, it is worth considering purchasing trolleys with ITS technologies already installed.
Maximize Bus Rapid Transit (BRT) opportunity/deployment	This is a specific opportunity that the region may be able to utilize. The BRT Corridor study that is underway is exploring Bus Rapid Transit in Sevier County, TN. The corridor would extend via SR 66 and US 441 from I-40 on the north to Gatlinburg. If a BRT system is implemented in Sevier County, there would be an opportunity to tie it to GRSM ITS initiatives.

TABLE 10. GRSM REGION OPPORTUNITIES

OPPORTUNITY	DETAIL
Leverage any road improvements planned to include ITS strategies or base technologies.	In the recently completed Foothills Parkway Analysis Final Report the possibility of limiting demand on the road to preserve an acceptable level of visitor experience was discussed. No specific strategies were evaluated. While the timeframe to construct sections of the Foothills Parkway is unknown, when sections are nearing the bid letting, it would be advantageous to include appropriate ITS technologies and backbone components in the bid package. This is the case for all upcoming roadway (and private developer) improvements. Improvements could include base ITS add-ons such as fiber optic and other utility conduit.
Leverage / Link TN ITS activities	Leverage TN ITS Activities – TDOT has a Statewide ITS Strategic Plan that is updating annually. This plan is intended to enable GRSM as their stakeholder to coordinate park efforts towards an integrated approach for ITS in Tennessee. As a geographic local entity, the park is listed as part of the Knoxville region. Integrating the GRSM ITS into TDOT activities is part of their scope. The Knoxville Regional ITS Architecture, first established in 2000, identified many instances of such integration with the park and with the Gateway communities.
Leverage / Link NC ITS activities	Leverage NC ITS Activities – The NCDOT ITS architecture for the region surrounding the park includes provision of tourist and traveler information that may include weather and accident response information. Truck safety is also an important factor in NCDOT's ITS architecture. NCDOT has implemented its 511 and has included National Park content. Variable message signs have been added to I-40 between the Tennessee state line and Ashville primarily to address rock slides and other incidents. NCDOT also has a roving Incident Management Assistance Patrol.

TABLE 11. GRSM REGION THREATS

THREATS	**DETAIL**
Many deployments require appropriate levels of information sharing among providers	Without appropriate levels of information (and possibly levels of system control) sharing, the intended technological benefits are likely to have an opposite impact. There is a natural reluctance to provide the degree of cooperation and collaboration necessary for successful ITS operations when the reaility of a deployment/operations is approaching.
ITS is not conventionally context sensitive for aesthetics, or environmental compatibility.	This threat could eliminate most if not all technological improvements from being considered for application. There is a strong desire to minimize or eliminate any visual or environmental disruption of the park
Targeting of transportation funding to other regions and projects that serve a more traditionally congested and urbanized environment.	This threat limits the available funding that National Park improvements may qualify for: • Transportation funding has been (or traditionally is) targeted to other regions and projects, serving traditional, more urban transportation needs. Also, ITS recommendations are often overlooked when compared to more traditional transportation improvements such as adding lanes of highway. Part of the reason why ITS improvements are often overlooked is that traditional transportation improvements are able to effectively demonstrate quantifiable benefits/impacts. • Transportation funds are typically diverted to highly congested and urbanized areas such as Washuington, DC, Los Angeles, etc.
Funding rules (e.g., FTA) may make it difficult to provide funding of tourist-specific services and projects.	This threat limits the available funding that National Park improvements may qualify. One criterion of select funding rules reduces the opportunity to fund tourist-specific services and projects.
ITS requires information to populate the systems	While ITS enhances operational and safety capabilities, without information in an ITS system, the usefulness of the system will decline. Information to be provided includes static, semi-static and real-time information. Static information includes regulations, restrictions, transit route and fare information and the like. Semi-static information covers construction and maintenance activities, and pre-planned events. Real-time information includes current operating conditions and events.

TABLE 11. GRSM REGION THREATS

THREATS	DETAIL
ITS relies on an organizational structure that includes some type of traffic/transportation management and operations.	Adding ITS to the park's organizational responsibilities is likely to overburden a structure that currently does not include transportation in the structure. There is an outstanding question of how/where to address new responsibilities in an existing organizational structure. Addressing how/what new structure could be implemented to support transportation and ITS issues is one means of addressing this threat.

ITS Strategies were next critically reviewed with respect to the above SWOT, to arrive at a list of ITS Strategies falling into three categories: Initial ITS Plan, Expanded ITS plan, and Full ITS Plan. This categorization implicitly considers potential resource constraints and project priorities. The selected ITS Strategies are presented in **Table 12**.

The process to refine Table 7, Weighted Matrix Results to Table 12, Selected GRSM ITS Strategies, was a qualitative application of the material contained in Tables 8 to 11 (Strengths, Weaknesses, Opportunities, and Threats). Also taken into consideration was an assessment of which Strategies need to be in place to support the deployment of the other strategies. For example, a centralized database is a strong merit Strategy in Table 12. In order to collect and track weather information and transit vehicle positioning in a gateway community, also Initial Plan Strategies, a central database needs to be in place. The Table 12 listing reflects such strategies, dependencies and reliabilities.

Also note that Table 12 contains some stand-alone strategies that were previously in the "Consider at a Later Date" category of Table 7. The previously discussed 511/IVR was not moved forward into the third screen as a stand-alone strategy. However, the Advanced Traveler Information System (ATIS) is contained in the third screen, due to its breadth of coverage. An ATIS consists of devices that collect, assimilate and disseminate information, and dissemination devices are a critical component of any ATIS. There are two categories of ATIS dissemination devices in Table 12, the first in the Initial Plan Strategies strategies, and the second in the Full Plan Strategies. Since 511/IVR takes advantage of existing systems and systems that are currently under development, it is included as a component of ATIS Dissemination in the Initial Plan Strategies.

TABLE 12. SELECTED GRSM ITS STRATEGIES

Initial ITS Plan	• Operational strategy development • Incident / Emergency Management Plans • Detour/alternate route plan development • Traffic detection • Road/Weather Information System (RWIS) • Air Quality Data Collection Equipment • Region wide maintenance and construction information provision • Central information database/ clearinghouse • Advanced traveler information system (ATIS) • ATIS Dissemination Devices – 511 / IVR, Internet/web, Highway advisory radio • Safe Zone/Work Zone systems • Transit AVL • Automated Parking Management System
Expanded ITS Plan	• GRSM Disaster Response and Recovery Plan • Park wide Emergency Alert System (EAS) • Data interfaces among participating organizations operations centers • Air quality alert/advisory system • Automated Incident / Emergency Management System (IMS/EMS) • Dynamic message signs • Computer aided dispatch (CAD) systems for transit. • Automated Gate System
Full ITS Plan	• Emergency operations information clearinghouse • ATIS Dissemination Devices – Broadcast radio • Operation center coordination / software • Automatic Vehicle Location (AVL) on park Vehicles • Automated Roadway Treatment System

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Section D: GRSM ITS Project Concepts

I. INITIAL PROJECT CONCEPTS

The first step to identify GRSM ITS Project Concepts was to revisit the selected ITS Strategies (shown above in Table 12, Section C) and for each strategy, to determine the functional features needed to assist in defining future projects. This was accomplished by referencing the USDOT National ITS Architecture to define for each selected ITS Strategy:

- Relevant subsystems and components
- Functional areas
- System requirements (with desirability noted)

Utilizing a combination of the National ITS Architecture material and the overall list of ITS Strategies, a listing of potential ITS Project Concepts was developed for GRSM to consider as applicable to meeting their needs. The Project Concepts were discussed among the Steering Committee members and the Core Team to ensure completeness and validity to meet GRSM needs. The resulting ITS Project Concepts, including Project Concepts added to address the three added ITS Strategies, were numbered for identification purposes (not as an indication of a priority order). The subsection below provides details on the concepts within the context of specific projects.

The functional features included in the project descriptions also were used as input to the USDOT's Turbo Architecture tool to create the "straw-man" ITS Architecture for GRSM. The architecture development process was progressing at the same time as the GRSM ITS Project Concepts, and that effort is fully described in Volume II of report.

II. PROJECT SCREENING

The GRSM ITS Project Concepts were then evaluated in a weighted matrix using the following criteria and weights:

Criterion:	Weight:
• Consistency with Themes	5
• Implementation Costs	2
• Operating and Maintenance Costs	3
• Operational Feasibility	4
• Extent to which Project Enables other Projects	1
• Extent to which Project builds upon or leverages other efforts	3

Scoring was performed with a 1, 2 or 3. A score of 1 is least desirable, 2 is desirable, and 3 is most favorable. The weighted matrix tool was used to rank order the GRSM ITS Project Concepts. Results of the weighted matrix were then further evaluated and separated into overall deployment priority categories: High, (H), Medium (M) and Low (L). The resulting prioritized list of 22 GRSM ITS Project Concepts is shown in **Table 13 –GRSM ITS Project Concepts.**

Those projects that have more than one rank are projects that have different aspects judged to have varying priority, as noted. In addition, some of the ITS Project have asterisks, indicating planning activities. Once the plan is finalized, the resulting activities may involve technologies, but to perform the Project Concept as presented, the result will be a plan. For example, Project Concept # 12 Incident/Emergency Management Planning involves the development of an incident and emergency management plan for GRSM and the surrounding region. The score or rank for these three was sometimes skewed due to "N/A" scores for some of the prioritization criteria.

Table 13 also presents information on which concepts led to specific development into ITS deployment projects (fourth column) as well as whether the resulting projects were subsequently tagged as "early start", immediate priority projects (last column). To help locate further details pertinent to these projects, the last two columns provide references to the appropriate text section of this report.

An additional four ITS Project Concepts (Project Concept 23, 24, 25, and 26) were subsequently added to the list because they are specific locations of interest, as determined by park staff. They can be thought of as "bundles" of the base 22 Project Concepts. The four were added after the weighted prioritization process.

As a result of this process, 14 of the 26 Project Concepts were identified for further development into specific projects. Appendix B presents an assessment of the technology options for all 14 concepts, covering a wide range of options. The appendix also includes an assessment of basic communications and power requirements to serve ITS technologies in the park. Subsequently, one of the 14 Project Concepts (#1 - Enhanced Wide-Area Communications System), was advanced by the NPS independent of this project, leaving 13 for further consideration in this planning effort.

TABLE 13. GRSM ITS PROJECT CONCEPTS

ID Number	Project Concept	Deployment Priority	Selected for ITS Deployment Plan	Early Start Project Identified
1	Enhanced Wide-Area Communications System	H	See Appendix B	
2	Maintenance and Work Zone-related Advanced Warning System	H	See Section E; See Appendix B	See Appendix C
3	Improved Real-time Traffic Information Services (ATIS – central database)	M-H	See Section E; See Appendix B	See Appendix C
4	Improved Traffic Monitoring and Detection	H	See Section E; See Appendix B	See Appendix C
5	ITS Communication and Power Needs Assessment*	H	See Section E; See Appendix B	See Appendix C
6	Improved Road, Weather & Air Quality Information Systems	M-H	See Section E; See Appendix B	See Appendix C
7	Enhanced Non-Auto Access to Park Facilities: Transit AVL	H	See Section E; See Appendix B	
8	Improved Real-time Information	H, L*	See Section E; See Appendix B	See Appendix C
9	Upgrade/Replace AM Radio Frequency 1610 (HAR) Stations	H	See Section E; See Appendix B	See Appendix C
10	Automatic Collection of Weather and Air Quality Information within GRSM	H	See Section E; See Appendix B	
11	Expand use of DMS within and on approaches to GRSM	M		
12	Incident/Emergency Management Planning*	L,M,H*	See Section E; See Appendix B	
13	Operational Strategy Development*	H	See Section E; See Appendix B	
14	Automated Incident / Emergency Management System	M		
15	Computer Aided Dispatch for Transit	M		
16	Operations Center Coordination	L		
17	Automatic Vehicle Location for Park Vehicles	L		
18	Automated Parking Management System	H	See Section E; See Appendix B	See Appendix C
19	Automated Roadway Treatment System	L		
20	Automated Gate System	M		
21	Improved RWIS capabilities	H	See Section E; See Appendix B	
22	Automatic RWIS	M		

High= High, M=Medium, L=Low   * Mixed priority, depending on activity.

III. GRSM ITS PROJECT DEVELOPMENT

The Core Team, Steering Committee and Stakeholders cooperatively generated 20 specific projects or incremental project components for further consideration and development. The projects reflect the collective input and judgment of the various entities and individuals interested in the long term welfare of the park. These 20 were next categorized by deployment time frame: Early Start (as soon as funded), Short Term (next 5 years), Medium Term (6-10 years out) and Long Term (11+ years out). A numbering scheme was developed in which each project was denoted as: X.1 for Early Start (eight projects), X.2 for Short Term (six projects), X.3 for Medium Term (four projects) and X.4 for Long Term (two projects), where X is the source Project Concept ID number.

The eight Early Start projects were further refined in terms of level of concept design, need for implementation agreements, potential procurement approach and cost estimate. The detailed further analysis of the Early Start projects is presented in Appendix C.

GRSM personnel next reviewed the eight in detail, then selected three for further development and cost refinement, as identified in Section E.

IV. ITS PROJECT CONCEPTS AND PROPOSED PROJECTS

Starting on the next page, all 26 original Project Concepts as well as the essential features of the 20 developed projects are presented. Titles of three of the ITS Project Concepts are *italicized* (Project Concept 5, 12 and 13) because they involve planning activities.

<u>Project Concept 1</u>

Enhanced Wide-Area Communication System

Due to limited capabilities to adequately provide communications throughout rural or park-like settings, when an emergency or maintenance need arises, it may be difficult to contact appropriate personnel. Enhancing area-wide coverage assists in enabling shorter incident detection times, quicker and more appropriate responses to accidents and maintenance events, reduced severity of accidents, and better utilization of park staff.

A radio communications upgrade was recently completed in response to Congressional mandate for revised communications migrating land mobile radio systems to a 12.5 KHz narrow bandwidth in the 162-174 MHz band. In 2004, GRSM let a contract to design and install equipment for the mandate. The completed installation is now being mapped, and there are believed to be some dead spots in the park.

Deployment of the new narrowband radio system in GRSM is now completed. The new system includes 9 sites linked by a microwave backbone system. The nine sites are located at Clingman's Dome, Cove Mountain, Fry Mountain, Look Rock, Mountain Sterling, Greystone Heights Cell Tower, Barnet Knob, Webb Mountain, and Wachacha Bald. All the sites except for Clingman’s Dome will have electric power; Clingman’s Dome will still be solar powered.

Because this concept has been separately advanced by GRSM, it is not under further consideration in this ITS deployment plan.

Project Concept 2

Maintenance & Work Zone-Related Advanced Warning System

Concept Description:

Maintenance and work zone areas can be dangerous to the workers, motorists and pedestrians passing through or near these areas. This is particularly true in the GRSM setting, where roadways have reduced roadway and shoulder widths, sharp curves, mountainous terrain, scenic views and driver frustration that may be experienced due to delays.

An advanced warning system alerting drivers of road and traffic conditions in the work zone can be beneficial to safety within these areas. Advanced warning systems may include many means of alerting drivers to these areas, including:

- Posting information on a website;
- Posting information at park entrances;
- Use of temporary static sign on approaches to the area;
- Use of Highway Advisory Radio (HAR);
- Use of Portable Changeable Message Signs (PCMS); and
- Use of Portable speed detection (PSD) mechanisms to alert drivers to excess speeds in work zones.

The Concept overall intends to provide advance warning of work zones and conditions, alert drivers relative to safe speeds within work zones, and provide alerts and warnings regarding incidents within work zones for operations/emergency personnel. It has led to the development of one Early Start project as follows.

Early Start Project 2.1 – Portable Work Zone System

The specific Project, “Portable Work Zone System”, utilizes temporary signs, temporary barriers, PCMS, and PSD devices as a means to provide adequate warnings of closures, detours and travel speeds in work zones within the park. The system will include the acquisition of a sufficient quantity of each component such that multiple (two) work zone operations can be maintained within the park and that sufficient equipment (including spare devices) is provided in order to support at least two (2) one-mile work zones.

The portability of the system will be assured through use of stand-alone power, adaptable either to solar, battery or generator power, along with the ability to mount the equipment on movable stands or trailers as required.

(see Appendix C for further details and cost estimate)

Project Concept 3

Improved Real-Time Traffic Information Services (ATIS central database)

Concept Description:

Providing near real-time information regarding roadway, parking and weather condition information in GRSM is a complex task that is a worthwhile pursuit. When the gateway communities unite with the park to share information that aims to manage traffic flow, congestion may be reduced, frustrations may be limited and park resources are likely to be preserved. gateway communities are considered the communities along the route to the park that may be impacted by park activities. Impacts may include transit service, traffic congestion and promotional activities where the park is considered a community attraction.

The ultimate concept is to provide an integrated central database and clearinghouse for real-time roadway, emergency, maintenance, weather and air quality information. It will (a) provide a single collection point for real-time information as above; (b) provide a central means for interfacing with other ITS projects which would provide such information to the public over a variety of methods, including Internet, 511 and other means which are accessible to the public; (c) permit sharing of information between GRSM, local agencies, and state DOT's (TDOT and NCDOT) so as to provide operational and condition information which is relevant both to state roads and to the park.

This concept has led to three specific projects, detailed below: 3.1 - ATIS Backbone Server, which is an Early Start project and was selected for detailed cost analysis by GRSM; 3.2 - Integrate Early Start/Legacy Systems with ATIS Server, and; 3.3 - Integrate New Deployments with ATIS Server. Proposed Early Start project 3.1 provides an initial step toward the broader information system needs, as described below. Each project expands upon earlier project(s) in building block fashion.

Early Start Project 3.1 – ATIS Backbone Data Server

The ATIS Backbone Data Server will compile currently collected transportation related information in the park into one database with a graphical user interface (GUI). Data will then be processed such that it can be geo-located on a GIS reference map incorporated into the ATIS Server and displayed for operators using a map interface. It is envisioned that the operator can select the appropriate map icons to tag the specific information related to that icon (e.g., construction, weather, closure, incident, or event). The information is envisioned to be entered will depict the event type, including location (road and direction), a short description (e.g., accident, fog, road construction), resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

In order to compile, format, and present the data in useful/user-friendly manner for the park users as well as support the future integrated ATIS services, it is advisable to consider the national ITS standards for interoperable information systems. The project will review the full range of standards available and consider using those that will aid in cost-effective system development and / or inter-system interoperability. The ITS-related national standards are designed to facilitate the efficient exchange of information and, as a result, have developed standard data elements and standard messages. Some of these standards, consistent with the national ITS architecture, are quite beneficial to system implementers in reducing the time and resources required to share information between transportation management systems and the 511 support systems.

Currently collected data includes construction and event information, regional weather information, and historical traffic data (from permanent and portable count stations already used in the park). Data collection is not part of this project. The Server will be based at a central location, and could eventually form the core system for a future traffic management or operations center to be developed by GRSM.

(see Appendix C for further details and cost estimate)

Short Term Project 3.2 – Integrate ATIS Server

With this project, the ATIS Backbone Data Server will be able to integrate information received from all automated systems (such as parking information, weather information, traffic data collected, and more). The graphical user interface (GUI) will be modified to reflect all data available after all the systems are integrated. Lessons learned from deployment of project 3.1 will be utilized in the fulfillment of this project.

In order to integrate the data in useful/user-friendly manner for the park users as well as support the future integrated ATIS services, it is advisable to consider the national ITS standards for interoperable information systems. The project will review the standards available and consider using those that will aid in cost-effective system development and / or inter-system interoperability. The ITS-related national standards are designed to facilitate the efficient exchange of information and, as a result, have developed standard data elements and standard messages. Some of these standards, consistent with the national ITS architecture, are quite beneficial to system implementers in reducing the time and resources required to share information between transportation management systems and the 511 support systems.

Medium Term Project 3.3 – Integrate New Deployments with ATIS Server

With this project, the ATIS Backbone Data Server will integrate information received from all new automated systems in GRSM. The graphical user interface (GUI) will be modified to reflect all data available after all the systems are integrated. Lessons learned from prior deployments will be utilized in the fulfillment of this project.

As in Project 3.2, in order to integrate the data in useful/user-friendly manner for the park users as well as support the future integrated ATIS services, GRSM will consider the currently avail-able national ITS standards for interoperable information systems.

<u>Project Concept 4</u>

Improved Traffic Monitoring and Detection

Concept Description:

The GRSM roadway network carries heavy traffic volumes in peak visitation months. Also, the escalating rate of accidents as well as traffic violations causes delay and frustration for park visitors. GRSM currently has very limited capability to monitor traffic conditions through the park to identify congested "hot spots" or where an incident (e.g., crash, stalled vehicle, fallen tree) may have just occurred. Current tools are focused on the collection of data for planning purposes, not for "real-time" monitoring. These tools include fourteen permanent traffic monitoring stations and seven portable counters that are used as needed by the park authorities. The collected data from the permanent counters is sent to NPS Field Operations Technical Support Center (FOTSC), based in Denver for processing, summary, and storage. The inability to monitor traffic flow information in real-time using the current tools means GRSM staff are unable to quickly identify, respond to, and clear incidents on park roadways. Hence, there is a critical need for better traffic monitoring and incident detection capabilities on the park roadway network.

The collection of speed data, combined with variable roadside signage, may reduce speeding and help reduce accidents on GRSM roads in addition to improving quality and quantity of traffic data used by traffic management & traveler information systems.

The ultimate vision is a multi-year planning, design and deployment effort, which will develop an enhanced traffic data monitoring, collection, and dissemination system for the GRSM region. The wealth of traffic data gathered using this enhanced data collection system will serve both as a tool to better monitor and manage traffic operations within the park and as a basis for informing travelers of specific conditions.

The concept has led to development of two specific projects: 4.1 – Initial Traffic Monitoring Sites which is an Early Start project and was selected for detailed cost analysis by GRSM, and; 4.2 – Expanded Traffic Detection/Monitoring. As the names imply, these are related projects in which the second builds upon the installed base of the first.

Early Start Project 4.1 – Initial Traffic Monitoring Sites

This project will concentrate on improving existing traffic data monitoring and detection capabilities, through deployment of data collection technologies such as inductive loops (sensors placed under the road) or non-invasive sensors (sensors placed above the road) at current data collection locations. Data collection technology will be determined on a location by location basis.

The prioritization of implementation sites and the technology to be deployed at each site will be guided by power and communication capabilities at existing traffic data monitoring and detection locations and input from park authorities. It may be possible to provide near-real time data collection depending on the current communication capabilities at some locations.

Traffic flow data would be collected through placement of unobtrusive detection devices. Poles "disguised" as trees or bushes have been used by the industry and could be considered an option. Small, well disguised equipment cabinets (e.g., NEMA Type B enclosures) would be mounted on pedestals at least 10 feet from the edge of pavement. The detectors themselves could be small, "non-invasive" devices not placed in the pavement, or traditional loop detectors located under the surface pavement course.

(see Appendix C for further details and cost estimate)

Short Term Project 4.2 – Expanded Traffic Detection/ Monitoring

Similar to Project 4.1, this project will concentrate on continuing to improve traffic data monitoring and detection capabilities, through deployment of data collection technologies at new locations. Data collection technology will again be determined on a location by location basis, and the process for technology selection is as described in Project 4.1.

<u>Project Concept 5</u>

ITS Communications and Power Needs Assessment

Concept Description:

The availability and reliability of electrical power and communications infrastructure are potential barriers to deployment of ITS devices and systems within GRSM. Unavailability of the electrical power in high/difficult terrain is one of the primary constraints for the ITS deployment within the park. Some methods to consider include solar power, electrical feeds network, UPS battery back-ups, etc. Comprehensive communications capabilities are critical to ITS deployment within the park. Some of the alternatives to be researched include continuous longitudinal cable network, wireless area network and fiber optics communications network.

The consultant selected to perform the transportation power and communication plan for GRSM will need to take into consideration the following factors: To implement ITS field equipment, both power and communications to the GRSM operations facility will be required at the specific field equipment locations. In light of limitations with solar power, any future detailed design will require definition of available power connections where solar panels are not a feasible option. Given that line-of-sight communications is not feasible from an environmental/aesthetic perspective, deployment of fiber optic and all types of wireless communications is to be considered.

While "one size fits all" may be the least complicated results to this type of study, it is likely that the communications and power requirements may differ enough that different alternative systems may be recommended. The study will recommend particular maintenance plans, including typical recommendations such a retaining an equipment vendor to provide maintenance and upgrades to system components for 1 to 3 year period with 2 one-year options (typical approach), as well as recommend the type and level of training that should be provided to GRSM staff on system control, communications and corresponding maintenance activities.

As a planning effort, there is a single Early Start project associated with this concept.

Early Start Project 5.1 – GRSM-Wide Detailed Communications and Power Needs Assessment

The objective of this project concept is to undertake a comprehensive review of existing facilities, proposed ITS project concepts, and identify appropriate power and communication technologies consistent with this project's themes, including environmental and preservation concerns. This study will undertake the study/development of a comprehensive transportation power and communications master plan for the GRSM Park. To ensure a comprehensive transportation master plan development, it is critical to consider existing as well as future needs (including ITS Deployments) for power and communications within the park.

The power element of the master plan will focus on researching and evaluating different methods of providing power for existing as well as future ITS equipment in the park. The project will develop a plan with recommendations for power source development for different technologies and locations within the park.

The communications element of the master plan will focus on researching and evaluating different methods of providing communications infrastructure within the GRSM Park. The project will develop a plan with recommendations for communications infrastructure development for different technologies and locations within the park.

The transportation power and communications master plan will also cover recommendations for contracting and procurement of recommended power and communications infrastructure.

(see Appendix C for further details and cost estimate)

Project Concept 6

Improved Road, Weather and Air Quality Information Systems

Concept Description:

GRSM routinely collects information from weather stations inside the park and the National Weather Service (NWS) and disseminates this information. The five locations in the park where weather information (temperature and rainfall) is collected are: LeConte, Newfound Gap, Oconaluftee, Sugarlands and Cades Cove. There are also eight air quality data collection sites within GRSM. Of these, six have regular telephone or cell phone connections, two use solar power, and two include digital cameras. Park staff dials-up the air quality data collection sites to download information. This weather information is shared via radio with park rangers, visitor centers, campground sites and other areas of high visitor concentrations.

The current sensor network provides limited road, weather, and air quality information. Data is collected manually and is updated only once a day. During inclement weather conditions, the weather along a stretch of road can change over very short time and distance. The weather severity differs with the roadway location. Having real time weather information at more locations will aid in decision-making by park staff. The overall safety of park's transportation network will be improved due to providing real-time (or continuously updated) weather and air quality information.

This concept has led to one Early Start project, as follows.

Early Start Project 6.1 – Integrate Existing Road Weather & Air Quality Information

This project focuses on integrating existing road weather and air quality information into the GRSM ATIS backbone data server (Project 3.1).

As the information is currently collected manually, the integration effort addressed in this project will include manual entry of the data collected into the ATIS backbone data server.

Integration of existing weather and air quality stations will enable park operations staff to more easily access this data, rather than sporadically sharing information via radio. More access to this information aims to enhance uniformity and reliability of the conveyed message, ultimately enhancing the park operations and the visitor experience.

Later projects may address upgrading and expanding the road weather and air quality information collection capabilities within GRSM park region. Future projects may be divided into upgrading existing weather and air quality stations, additional integration of information collected, and examining the need for additional stations.

(see Appendix C for further details and cost estimate)

Project Concept 7

Enhanced Non-Auto Access to Park Facilities: Transit AVL

Concept Description:

One of the best ways of reducing congestion and preserving the park is to offer alternative means (besides personal autos) to access and/or travel around the park. This strategy also reduces the number of vehicle trips into and around the park. This can be accomplished through encouraging the use of public transportation / trolley use and by promoting cycling, walking and hiking. One benefit of enhancing non-auto access is reduced parking issues. A secondary benefit is a more interactive visitor experience.

This Project Concept focuses on encouraging the use of public transportation and trolleys for access to GRSM and travel within the park. The feasibility of enhanced GRSM bus/trolley services would be conducted in close coordination with gateway communities and local/regional public transportation service providers.

The use of AVL systems on transit vehicles providing service to the park would enhance the quality of service provided to visitors and further encourage transit use. Such AVL systems are envisioned to be compatible with and build upon the lessons learned by gateway communities (such as Gatlinburg Transit) with existing or proposed AVL and "Next Bus" type technologies. Use of AVL systems on transit vehicles has the potential both to improve the efficiency of transit operations and to support traveler information systems in GRSM and gateway communities.

This concept has led to one medium term project in the initial ITS Deployment Plan

Medium Term Project 7.3 – Implement Transit Vehicle Tracking (by others)

The use of AVL systems for transit vehicles that enter the park would enhance the quality of service provided to visitors and would further encourage transit use. AVL system information in the area (such as Gatlinburg Transit systems) would be valuable to GRSM's expanding ITS Program deployment.

A fully deployed transit AVL system makes transit a more viable transportation option by improving public perception, transit traveler information, and operations. The more park visitors ride transit as opposed to driving private vehicles, the fewer vehicles will be traveling on park roadways where buses travel. This leads to decreased air pollution and increased preservation. Sharing of AVL information with GRSM (especially at the visitor centers and other transit stops within the park) will enhance the visitor experience to GRSM. Park visitors will benefit from transit AVL as accuracy of transit arrival and departure times increase. A park visitor will know when the transit vehicle is due to arrive, and therefore, can plan his or her time more effectively.

GRSM's level of effort for this project includes encouragement of regional transit providers to deploy transit AVL systems, and, once deployed ensure that information sharing agreement(s) between GRSM and with the regional transit providers are in place. Options to provide this information at GRSM visitor centers includes kiosks, autodial telephones (where the user simply picks up the phone and hears the estimated time of arrival for the next bus), and video displays (such as airline displays) at bus stops.

Project Concept 8

Improved Real-Time Information

Concept Description:

The overall Project Concept 8 focuses on the dissemination of consistent, near real-time information on road conditions within and around the park. It also addresses any institutional issues related to the sharing of information between GRSM, gateway communities and regional agencies. The intended audience of such information includes visitors, park personnel, and other information service providers, such as local visitor centers, chambers of commerce, local hospitality industry staff and television/radio stations.

There are several existing information resources available to assist the first time visitor or those unfamiliar with the area. However, information provided by those sources is likely to be static/unchanging information, likely to be old and not readily available when needed by the first time visitor. Examples of these existing sources of information included local television and radio stations (traffic and weather information), area visitor centers, chambers of commerce, and employees of local restaurants and hotels. In addition to not being current, the information at such sources may not be consistent in quality.

NCDOT currently provides an option to the callers interested in obtaining current GRSM information within their 511 system.

This Project Concept is supported by other Project Concepts: Project Concept 3 – Improved Real-time Traffic Information Services; and Project Concepts 4, 6, 9 10, and 11. It has led to four specific projects: 8.1 – Initial Internet-Based Dissemination, which is an Early Start project and was selected for detailed cost analysis by GRSM; 8.2 – Add Real-Time Traffic/Parking Data to ATIS,; 8.3 - Add Shared Traffic & Incident Data to ATIS, and 8.4 - Add Automated Road, Air Quality, Weather & Transit Info to ATIS,. Proposed Early Start project 8.1 provides an initial step toward the broader dissemination of travel time information. Each subsequent project expands upon the coverage of prior projects.

Early Start Project 8.1 - Initial Internet-Based Dissemination

Project 8.1, will provide an Internet-level server which is capable of providing GRSM traveler information to the public using the web. This deployment will focus upon the data which is input into the ATIS Backbone Data Server (3.1) – roadway construction, event, and closure information as well as weather information. The information will be available to the public both as a listing and related geographically to a park map showing roadways and points of interest. This project also will disseminate GRSM's ATIS database (Early Start Project 3.1) to existing web-based traveler information systems in the surrounding communities (such as the NCDOT and TDOT 511 systems) – up to three (3) interfaces. The functional requirements for the web-based dissemination system will be developed by EFL or the GRSM-selected technical consultant.

(see Appendix C for further details and cost estimate)

Short Term Project 8.2 – Add Real-Time Traffic/Parking Data to ATIS

Project 8.2 will provide as much real-time travel and parking information as is available within GRSM to the GRSM traveler information website. The information will be available to the public both as a listing and related geographically to a park map showing roadways and points of interest. This project also will disseminate GRSM's traveler information website to existing web-based traveler information systems in the surrounding communities (such as the NCDOT and TDOT 511 systems). The functional requirements for the web-based dissemination system will be developed by EFL or the GRSM-selected technical consultant. A website update will be necessary for deployment of this project.

Medium Term Project 8.3 – Add Shared Traffic and Incident Data to ATIS

Project 8.3 will integrate traffic and incident information from the gateway communities and other service providers and post it on the GRSM traveler information website. The information will be available to the public both as a listing and related geographically to a park map showing roadways and points of interest. This project also will continue to disseminate GRSM's traveler information to other existing web-based traveler information systems in the surrounding communities (if appropriate agreements are reached to do so). A website update will be necessary for deployment of this project.

Long Term Project 8.4 – Add Recent Deployment information to ATIS

Project 8.4 will integrate all new ITS deployment information to the GRSM traveler information website. The information will be available to the public both as a listing and related geographically to a park map showing roadways and points of interest. This project also will continue to disseminate GRSM's traveler information to other existing web-based traveler information systems in the surrounding communities (if appropriate agreements are reached to do so). A website update will be necessary for deployment of this project.

Project Concept 9

Upgrade/Replace AM Radio Frequency 1610 Stations

Concept Description:

Highway Advisory Radio (HAR) systems offer a low cost (cost for HAR is substantially less than other forms of dissemination), effective (easily accessible for drivers and provides more detail than variable message signs), and easily deployable (no licenses required) travel information solution for park authorities. The current system is of limited use for park authorities as it is very old and has very limited coverage. The current GRSM HAR system has twelve stations broadcasting at various locations within the park. Today, owing to lack of maintenance limitation and lack of available parts, only three of twelve stations are operational. The existing system requires staff to travel to each location to modify or change the message.

A fully automated HAR system is one in which the information broadcast over the HAR system is initiated by the centralized travel/transportation information database. A system of this type was deployed and operated in Branson, Missouri. The Branson HAR system included several hours of HAR message storage. Messages were recorded by various individuals (to reduce the monotone-sound that most HAR systems use) and addressed transportation events (congestion, road closures, weather, special events, scheduled maintenance), required messages (station identification, time, date), and local information (greetings, seasonal visitor information, website addresses). The Branson HAR was programmed to play messages that aligned with information as it became available in the centralized transportation database according to a pre-planned message organization. The message "loop" in the Branson system was 15 minutes. The pre-planned message organization was determined by the transportation and emergency service providers in the area. The format addressed up-to-date event information once every two minutes, time and date stamp once every 15 minutes, and a random selection of local information to be broadcast.

This concept has led to development of one Early Start project as follows.

Early Start Project 9.1 - Upgrade/Replace AM Radio Frequency 1610 Stations

The existing HAR system will be upgraded with an upgraded HAR system to possibly allow for dial-up HAR message changes and to expand the current area of coverage. Determination will be made as to whether or not dial-up capabilities exist at each current/existing HAR location.

The latest HAR technology will be considered in an aim to allow park authorities to remotely program and disseminate information. GRSM's updated HAR system will include intelligence – in that it will be able to detect and identify when the ATIS database threshold has changed and automatically update the messages on the HAR. The system will include message storage capabilities for pre-recorded HAR messages. Whether there are adequate communication capabilities at each site, each upgraded system will contain this capability. Enhancements to the GRSM communication capabilities may be made in the future – when they exist, the automated HAR systems will hopefully be ready to operate in the automated mode.

When appropriate, GRSM should consider deploying a fully automated HAR system once all other identified projects are deployed.

(see Appendix C for further details and cost estimate)

Project Concept 10

Automatic Collection of Weather and Air Quality Information

Concept Description:

This Project Concept is similar to Project Concept 6; the difference is that it aims at the automation of collection of weather and air quality information within GRSM. At the present time there are five official weather collection locations in the park where weather information (temperature and rainfall) is collected. None of these are automated and each requires a Ranger to stop at the location and read the information.

There are currently eight air quality data collection sites within GRSM. Of these, six have regular telephone or cell phone connections, two use solar power and two include digital cameras. Park staff dials-up these data collection sites to download information.

Automating collection of the weather and air quality information ensures consistent data collection and transmission efforts for GRSM, significantly reducing labor efforts on park staff.

This concept has led to development of one Medium Term project as follows.

Medium Term Project 10.3 – Automate Weather & Air Quality Measurement Systems

This project focuses only on the automation of collection of weather and air quality information within GRSM. The automation of data collection will enable the field equipment to 'push' the weather and air quality information gathered by the sensors to GRSM operations center (Central Equipment), thus, avoiding the need for staff to physically go to each weather station to download the data. There are several weather and air quality sensors available that are capable of pushing the data back to the central equipment at a pre-determined periodic interval.

Automating collection of the weather and air quality information ensures consistent data collection and transmission efforts for GRSM, significantly reducing labor efforts on park staff. Automatic collection means that GRSM staff does not have to go to each device nor will they have to contact (dial-up) each site – the deployed weather and air quality devices "push" the data collected to the GRSM central database. Appropriate power and communications connections will need to be in place to support this deployment.

Project Concept 11

Expand use of DMS within and on approaches to GRSM

Concept Description:

Two Dynamic Message Signs (DMSs) have been constructed to advise motorists of important information regarding park conditions and activities. These DMS signs were specially designed as a potential model for other NPS units and were deployed as an early action. One sign is located in the southbound direction near Sugarlands Visitor Center. The second sign is located northbound at the park entrance in North Carolina. Programming and operation of these signs will be the responsibility of the Communications Center at Park Headquarters. These signs are operational at this time – accepted by the park in October, 2004. The signs have provided several operational challenges for GRSM staff – the first of which was an improper solar system design that greatly overestimated the solar resources available in the park. Other problems included the signs fogging up and current problems where the operators must go to the sign to change the message. The latest issue requires a software change/upgrade as well as updating the sign controller to allow the remote computer and the DMS to communicate.

This Project Concept examines the feasibility of expanding the use of DMS within and around GRSM as a component of an Advanced Traveler Information System (ATIS). Lessons learned during the design, implementation and initial operation of the first two DMS will be incorporated into the feasibility study, as will the experience and usage of DMS by other local and regional agencies.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project in the initial ITS Deployment Plan.

Project Concept 12

Incident/Emergency Management Planning

Concept Description:

The primary objective of this Project Concept is to develop Incident / Emergency Management Plans for GRSM. This Project Concept includes the following components:

- Review existing GRSM incident / emergency policies and procedures;
- Review existing incident / emergency planning activities in gateway communities and among regional agencies;
- Develop detour / alternate routes for use when major incidents / emergencies occur within GRSM;
- Develop a GRSM Disaster Response and Recovery Plan;
- Coordinate with gateway communities and regional agencies in the development of regional incident / emergency management plans; and
- Coordinate with other GRSM ITS Project Concepts that impact or are impacted by incident / emergency management activities.

This Project Concept addresses a number of short, medium and long term strategies. As such it may be broken down into multiple phases or be considered as an ongoing, continuous planning and implementation process. It has led to the development of one Short Term project as follows.

Short Term Project 12.2 – Incident and Emergency Planning Assessment

The objective of this study is to undertake a comprehensive review of existing facilities, incident and emergency response procedures, up to five noteworthy events, and generate GRSM best practices for incident and emergency management activities. This study will undertake the study/development of a comprehensive incident and emergency management master plan for the GRSM Park. To ensure a comprehensive transportation master plan development, it is critical to consider existing as well as future needs/opportunities (including ITS Deployments), and external service providers for incident and emergency management activities within the park.

Project Concept 13

Operational Strategy Development

Concept Description:

This Project Concept is to develop the operational strategies necessary to support the implementation, operation and maintenance of equipment, systems and services resulting from other GRSM ITS projects. As such it focuses on policies and procedures related to operations and maintenance, as well as staffing needs to support enhanced GRSM systems and services.

Short Term Project 13.2 – Operational Strategy Assessment

The goal of this planning project is for GRSM to meet with and discuss applicable strategies from a region perspective – toward regional transportation operations. This planning project focuses on developing high level policies and procedures to facilitate planning, deployment, and operations for ITS systems, elements, and services between gateway communities, park authorities, and other regional agencies. This planning project builds on the established relationships provided by the ITS Strategic Planning project. Effective and frequent communications among the regional service providers aims to ensure efficient coordination with regional agencies for ITS operations. This planning project helps facilitate the development of a regional ITS operational strategy including agreements and clearly defining the roles and responsibilities for each involved agency. Internally, the operation strategy will also help define operations and maintenance responsibilities for the GRSM divisions.

Project Concept 14:

Automated Incident / Emergency Management System

Concept Description:

This Project Concept, while related to Project Concept 12, focuses on the feasibility, design and implementation of:

- Automated Incident Detection System for the Park Spur;
- Automated Incident / Emergency Management Systems; and
- A Park wide Emergency Alert System (EAS).

This Project Concept builds upon existing GRSM systems and draw upon the experience of other national parks in developing and operating these systems, within the context of a park environment.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 15

Computer Aided Dispatch for Transit

Concept Description:

This Project Concept builds upon the findings of Project Concept 7, Enhanced Non-Auto Access to Park Facilities, to examine the feasibility of computer aided dispatch (CAD) systems for transit systems that travel within GRSM and gateway communities. Such a CAD system supports and enhances existing or planned demand responsive transit services (para-transit) in the region.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 16

Operations Center Coordination

Concept Description:

This Project Concept supports a number of other proposed Project Concepts by focusing on issues relating to coordination between traffic operation centers in the region, including GRSM, TN DOT, NC

DOT and other traffic management / transit operation centers. Other Project Concepts supported by this project include Concepts 3, 8, 12, and 13.

It addresses the feasibility of sharing resources and coordinating operational strategies among regional management centers. Examples of resources to be shared could include CCTV images, transit vehicle location data, etc. By contributing to the coordination of operational strategies, this Project Concept also supports Project Concepts 3 and 13. The concept focuses on policies and procedures related to operational centers, as well as staffing needs to support enhanced GRSM systems and services.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 17

Automatic Vehicle Location for Park Vehicles

This potential long-range Project Concept examines the feasibility of equipping park vehicles with automatic vehicle location (AVL) technologies to assist in the efficient monitoring and utilization of GRSM resources. This Project Concept builds upon the experience and lessons learned in Project Concept 7, Enhanced Non-Auto Access to Park Facilities: Transit AVL.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 18

Advanced Parking Management System

Concept Description:

Parking lot overflow damages the terrain. However, park visitors want to come into the park and experience the beauty of the park and are often not deterred by finding full parking lots. Instead many visitors will park along roadsides close to full parking lots, creating driving hazards and impacting park resources.

Parking management is also a vital issue for efficient park traffic operations owing to recirculation traffic in the park due to lack of parking and information regarding parking. Hence, an efficient parking management and parking information dissemination is critical for improved traffic operations within GRSM park region. Technology advances have provided several advanced parking management options to assist in this respect.

Parking management systems may include deployment of detectors, some type of central software and dissemination devices or systems. A parking management system is typically integrated into traveler information systems, where available, and can also be used to support efforts to encourage alternative modes of transportation to and within the park.

Parking management systems may include deployment of detectors (capacity monitoring), some type of central software (reporting system) and dissemination devices or systems (Driver information).

This concept led to development of two specific projects: 18.1 – Parking Information System – Initial Site, which is an Early Start project, and; 18.2 – Parking Information System Expansion – Additional Sites. As stated, the second builds upon the first.

Early Start Project 18.1 - Parking Information System – Initial Site

An Early Start parking management system project is recommended to be deployed at the Chimneys Picnic Area parking lot. GRSM will procure the services of a parking management consultant to assist GRSM in the project management design – developing all desired messages to be displayed to the motorists and what actions to take when the lot is full – deployment, operational support, and evaluation/lessons learned report preparation. The early start parking management system hardware and software, when procured, will include parking access traffic count detection, along with small variable message signs along the road indicating the parking availability in advance of the parking lot. Currently available power and communications will be utilized in this deployment. The basic parking management design of this parking system will be evaluated for possible future deployments at other congested parking locations (typically near trailheads and in the Cades Cove area).

(see Appendix C for further details and cost estimate)

Short Term Project 18.2 – Parking Information System Expansion – Additional Sites

GRSM will procure the services of a parking management consultant to assist GRSM in the project management design – developing all desired messages to be displayed to the motorists and what actions to take when the lot is full – deployment, operational support, and evaluation/lessons learned report preparation. The parking management system hardware and software, will integrate lessons learned from deployment of project 18.1 in the fulfillment of this deployment. It is envisioned that parking management systems within GRSM will include parking access traffic count detection, along with small variable message signs along the road indicating the parking availability in advance of the parking lot. Power and communications capabilities may need to be provided for this deployment.

Project Concept 19

Automated Roadway Treatment System

In conjunction with Project Concepts 10, 21, and 22, this Project Concept aims to identify ways to provide automatic treatment of roadways during winter weather. Some of the treatments include fog dispersion, spreading of eco-friendly anti-icing chemicals, etc. This Project Concept involves monitoring the roadway surface conditions using different weather and infrastructure sensors to detect potentially dangerous driving conditions and automatically trigger response to such conditions. This project also involves tying such sensors with the roadway traffic information dissemination devices to alert drivers about potentially dangerous roadway conditions.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 20

Automated Gate (Roadway Closure) System

In conjunction with Project Concepts 6 and 10 or 21 and 22, this Project Concept aims to deploy ways to close roadways to vehicular traffic when driving conditions are unsafe, maintenance must be performed, and other scenarios where access to the roadway must be prohibited or controlled. This project involves installation of automatic or remotely controlled gates or barriers that control access to roadway segments including ramps and traffic lanes. The environmental sensors monitor pavement conditions and activate roadway closures automatically or from a remote location via remote controllers. Remote control systems allow the gates to be controlled from a central location or from a vehicle at the gate/barrier location, improving system efficiency and reducing personnel exposure to unsafe conditions during severe weather and other situations where roads must be closed. Surveillance systems allow operating personnel to visually verify the safe activation of the closure system and driver information systems (e.g., DMS) provide closure information to motorists in the vicinity of the closure.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

Project Concept 21

Improved RWIS capabilities

Concept Description:

This Project Concept includes the improving/updating of existing weather information collection sites within the GRSM and addition of new sites, as necessary. It also encompasses road condition monitoring sites (measuring surface and sub-surface temperature, moisture, icing, salinity, etc). The updated system is proposed to include communications of data to the park and integration with other related data in a central information database/clearinghouse for GRSM (Project Concept # 3). The difference of this Project Concept over Project Concept 6 is that this concept only addresses the weather elements of all the GRSM environmental sensors. The air quality sensors are not addressed in this Project Concept.

This concept led to the development of one Long term project as follows.

Long Term Project 21.4 – Enhance and Expand RWIS

This project proposes improving/updating existing weather information collection sites (as necessary) within the GRSM and the addition of new sites to collect information on the road pavement conditions. The updated system envisioned in the project is proposed to include data communications to the park communications room and integration with other related data in a central information database/clearinghouse. Adequate power and communication capabilities will need to be deployed prior to this deployment at the identified sites.

As part of this project, environmental sensor station (ESS) will be strategically placed to monitor road conditions. ESSs can measure a range of weather-related conditions, including pavement temperature and status (wet, dry, snow), subsurface pavement temperature, wind speed and direction, precipitation (amount, occurrence, type), water level conditions, humidity, and visibility. These sensors are capable of and are proposed to provide more timely and complete information than the current method of periodic ranger patrols and will form a road weather information system (RWIS) to provide park managers with needed information for informed operational decisions (when and where to send road crews, when to close Newfound Gap Road, etc.).

Project Concept 22

Automatic RWIS

This Project Concept is similar to Project Concept 21, the difference is that it aims at the automation of collection of weather and air quality information within GRSM. At the present time there are five official weather collection locations in the park where weather information (temperature and rainfall) is collected. None of these are automated and each requires park staff to stop at the location and read the information.

Automating collection of the weather and road surface information ensures consistent data collection and transmission efforts for GRSM, significantly reducing labor efforts on park staff. The difference of this Project Concept over Project Concept 10 is that this concept only addresses the weather elements of all the GRSM environmental sensors. The air quality sensors are not addressed in this Project Concept.

This Project Concept was not deemed to be high priority at this time and thus not developed into a proposed project for the initial ITS Deployment Plan.

The next four Project Concepts are for Implementation Planning/System Design for certain areas of interest within the park that are currently under separate studies. All four are considered to be of high interest to GRSM Staff and would be explored further as their associated projects advance.

Project Concept 23: Cades Cove ITS Implementation Planning/System Design

This Project Concept will identify systems that address current and specific problems and issues in the Cades Cove area such as a lack of parking and pull-off areas and extreme traffic congestion. As such, this Project Concept addresses traffic monitoring, traffic information, transit usage, a reservation system, and other measures to alleviate congestion while preserving the environment.

Project Concept 24: Newfound Gap Road ITS Implementation Planning/System Design

This Project Concept will identify systems that address current and specific problems and issues along Newfound Gap Road. Newfound Gap Road has significant traffic volume when compared to the other park roadways. It is the only road that continues through the park. Safety has been at the forefront of Newfound Gap Road's issues. Another issue is balancing the tourist traffic pace with the vehicles that prefer to drive through the park at a more consistent pace. As such, this Project Concept addresses incident and traffic management issues.

Project Concept 25: GRSM Spur Road ITS Implementation Planning/System Design

This Project Concept will identify systems that address current and specific problems and issues on the Spur Road. The Spur is the park road with the greatest speeds and traffic volumes. It is a four-lane, divided roadway that caters to signification amounts and types of vehicular traffic (including transit vehicles and commercial vehicles). The Spur has significant safety and through-traffic issues. Speeding is a problem and typically more car crashes occur on the Spur than any other GRSM road except Newfound Gap Road. As such, this Project Concept addresses incident and traffic management issues.

Project Concept 26: Winter Road Maintenance ITS Implementation Planning/System Design for Newfound Gap Road

This Project Concept will identify systems that address current and specific problems and issues along Newfound Gap Road during the winter season. As Newfound Gap Road is a through road, many local drivers rely on that roadway being open throughout the year. When the roadway becomes unsafe to travel in the winter season, park staff closes the road. This presents many problems. This Project Concept addresses identifying means of keeping Newfound Gap Road open during winter months and/or identification of a more reliable means of assessing roadway conditions, closing the road, and communicating the status of the roadway in an effective and reliable manner.

Section E: ITS Deployment Plan

I. OVERALL PLAN

The ITS Deployment Plan for GRSM has been developed as a phased series of interdependent projects that aim to address the themes and ITS vision of GRSM. Much like building a major structure, the GRSM ITS vision will rely on foundational efforts to underpin other elements, and there will be many linkages between the elements, in this case projects, that need to evolve over time. Both the foundational aspects and the linkages are captured in the deployment strategy graphic presented on the next page.

The graphic presents all proposed projects, with numbering to represent the proposed timing of each project. Selected GRSM Project Concepts are identified in the left-most column of the graphic. Proposed Early Start projects are shown in the darkest color boxes, in the second column from the left. The Early-, Medium-, and Long-term projects are shown in lighter colors as the reader moves to the right. The solid lines between projects identify the logical work progression as well as general information inputs from one project to another. The dashed lines illustrate important linkages between projects relating information from the first project that must be used to plan, design and implement a second project.

The ITS Deployment Plan has been developed using a systems engineering approach that is comprehensive in setting overall vision, concepts and requirements, then proceeding to design, implementation and operations in an iterative manner. Subsection III. presents more detail on the systems engineering approach.

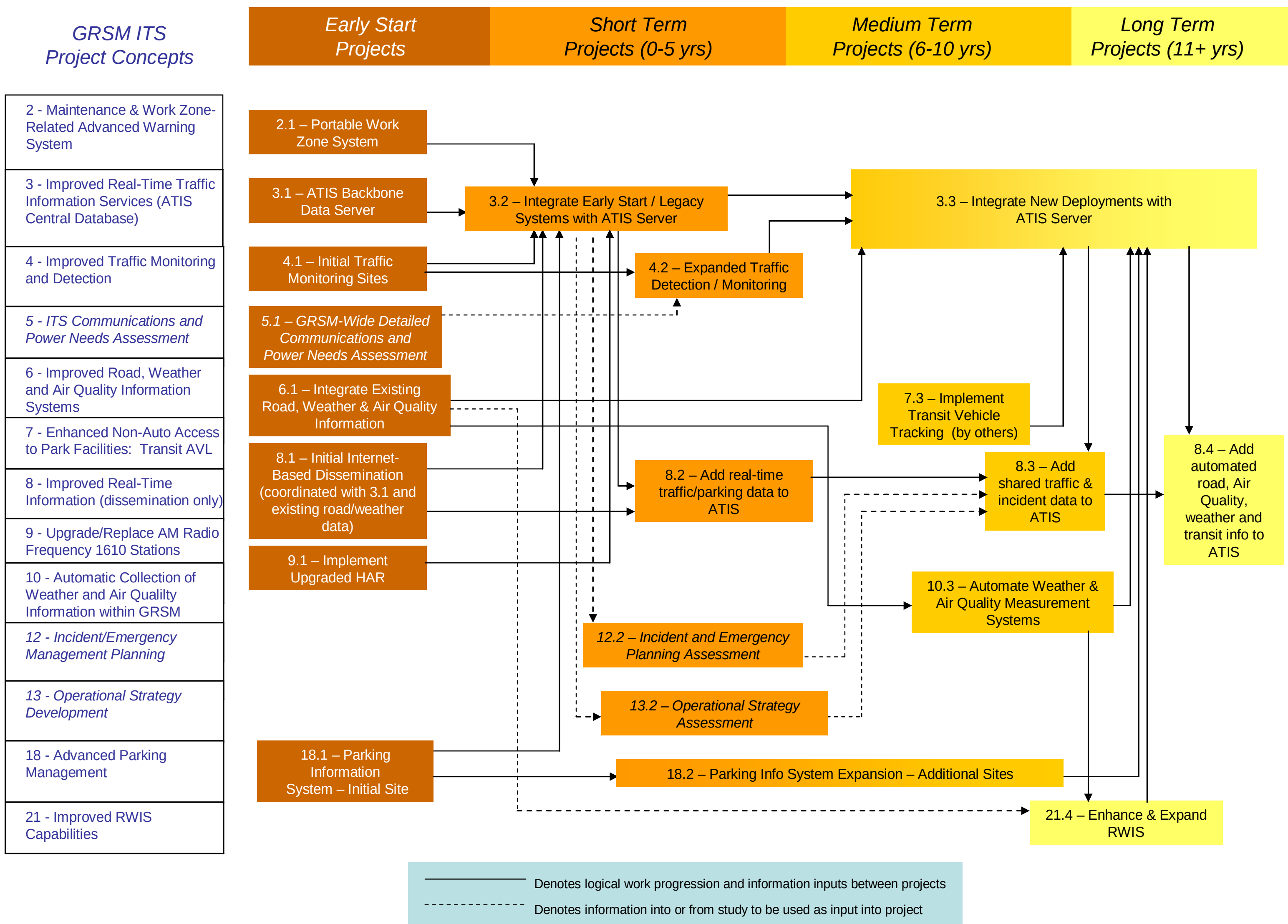
II. GRSM SELECTED PROJECTS

As previously mentioned, GRSM personnel critically reviewed the eight Early Start projects, then selected three for more detailed conceptual design and cost estimation. The three projects are: 3.1 – ATIS Backbone Data Server, 4.1 – Initial Traffic Monitoring Sites, and 8.1 – Initial Internet-Based Dissemination. The aim is to make these three the highest priority projects for immediate implementation, because they will provide the greatest overall benefit to both operators and patrons of the park, and will support several subsequent projects.

Appendix C presents more detailed information about these three projects covering procurement approach and agreements needed to make the projects work. Life cycle cost analysis has also been completed for the three, in conformance with the requirement for systems engineering analysis for all federally funded ITS projects, thus positioning them for immediate federal support (see Section F). The estimated costs for each of the projects is:

3.1 – ATIS Backbone Data Server	$ 225,000
4.1 – Initial Traffic Monitoring Sites	$ 520,000
8.1 – Initial Internet-Based Dissemination	$ 133,000

GREAT SMOKY MOUNTAINS NATIONAL PARK ITS DEPLOYMENT STRATEGY



III. SYSTEMS ENGINEERING APPROACH FOR PROJECT DEVELOPMENT

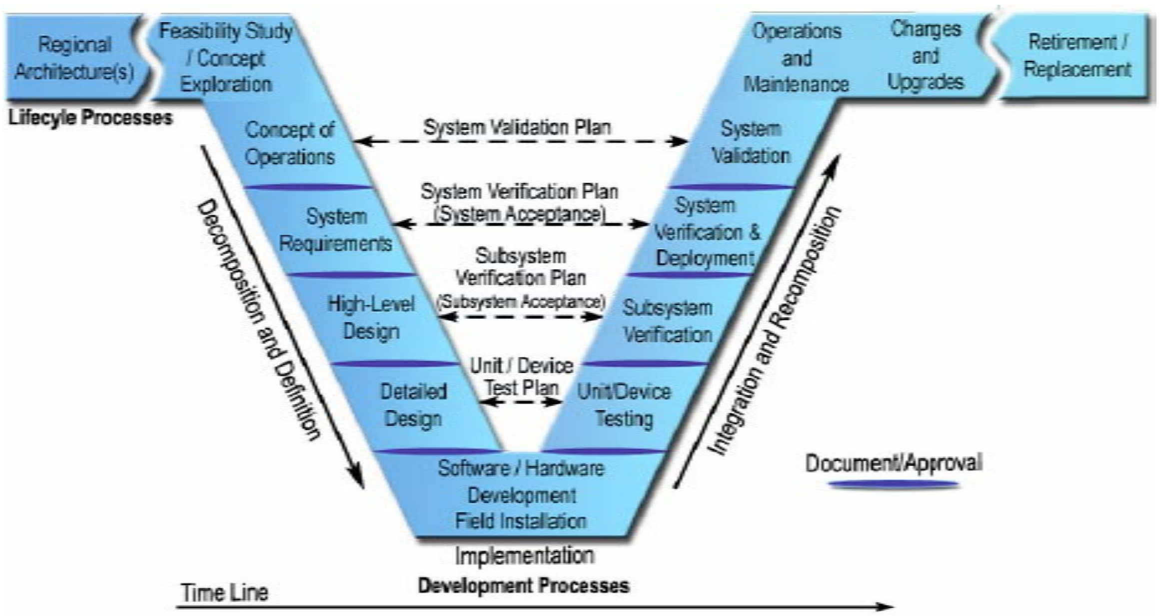
Since the Federal Lands Highway Program (FLHP) Park Roads and Parkway Program falls under USC Title 23, GRSM ITS projects funded by the FLHP are subject to the federal ITS Architecture regulation (23 CFR Parts 655 and 940, "Intelligent Transportation System Architecture and Standards," January 8, 2001). The Rule/Policy requires a systems engineering analysis to be performed for ITS projects, and specifies seven requirements that the systems engineering analysis must include at a minimum:

(1) Identification of portions of the GRSM ITS architecture being implemented;
(2) Identification of participating agencies' roles and responsibilities;
(3) Requirements definitions;
(4) Analysis of alternative system configurations and technology options to meet requirements;
(5) Procurement options;
(6) Identification of applicable ITS standards and testing procedures; and
(7) Procedures and resources necessary for operations and management of the systems

The primary benefit of completing systems engineering is that it will reduce the risk of schedule and cost overruns and will provide a system of higher integrity. Other benefits include:

- better system documentation,
- higher level of stakeholder participation ,
- system functionality that meets stakeholders' expectation,
- potential for shorter project cycles,
- systems that can evolve with a minimum of redesign and cost,
- higher level of system reuse, and
- more predictable outcomes from projects .

The Rule allows the NPS in cooperation with FHWA/FLH to use a systems engineering approach that is tailored to fit the needs of each ITS project. The systems engineering approach is actually broader than the seven specific requirements identified in the Rule. The so-called "V" model is emerging as the de facto standard way to represent systems engineering for ITS projects, as follows.



The left wing shows the GRSM ITS architecture, and the feasibility studies and concept exploration performed as part of this ITS study that support initial identification and scoping of the identified ITS projects. The following steps in the "V" are for the specific ITS projects. The central core of the "V" shows the project definition, implementation, and verification processes. The right wing shows the operations and maintenance, changes and upgrades, and ultimate retirement of the system.

As shown in the "V", the systems engineering approach defines project requirements before technology choices are made and the system is implemented. On the left side of the "V", the system definition progresses from a general user view of the system to a detailed specification of the system design. As the system is decomposed into components, the requirements are also decomposed into more specific requirements. As development progresses, a series of documented baselines are established that support the recomposing steps that follow, namely for testing, verification and validation, which helps determine whether the system was built correctly and then whether the right system was built. The dashed lines in the center indicate that this is an iterative process in that lessons learned from testing, operations and emerging technologies over time are used to update and revise the concept of operations, system requirements and design.

The work performed in this study provides information for each project identified in the GRSM ITS Deployment Plan to effectively perform these project development procedures.

Section F: Funding Issues

I. POTENTIAL PUBLIC SOURCES OF PROJECT FUNDING

Transportation in the Great Smoky Mountains National Park has been supported for many years with traditional sources of funding. To successfully implement ITS projects at GRSM, the park may need to pursue various means of funding projects including public/private partnerships and new tools available on both the federal and possibly, state levels.

A. National Park Service Funding Options

GRSM identified a significant number of National Park Service funding sources, however most are not relevant to transportation projects. Those that might be applicable include:

- Air Quality – Ecological Effects – Fund Type 01: This may apply to specific ITS projects, but not the three early-start projects.
- Annual Operating Funds or Park Base (Recurring) – Fund Type 01: This is the primary source of operational funding for parks, not applicable for funding new projects, though a request for an operating fund increase would typically accompany a new project.
- Challenge Cost-Share – Fund Type 01: Program provides a maximum of 50% cost-share grant to expedite and complete mutually beneficial projects with outside sources. The purpose is to increase awareness and participation by both neighboring communities and the public at large in the preservation and improvement of National Park Service recreational, cultural, and natural resources.
- Donations – Fund Type 26: parks are authorized to use donated funds to meet the purposes of the National Park Service.
- Park Roads and Parkway Program (PRP) – Fund Type 44: The National Park Service portion of the Federal Lands Highway Program (FLHP) provides for the repair, rehabilitation, and reconstruction of park roads, parkways, and bridges. While work generally involves planning, research, engineering, and construction, funds available for Park Roads and Parkways are available for any kind of transportation project eligible for assistance under Title 23 that is within or adjacent to or provides access to the areas served by Park Roads.
- Line-Item Construction – Fund Type 05: Major construction and reconstruction projects which generally require a three-year schedule for completion.

<u>Federal Lands Highway Program (SAFETEA-LU Section 1119)</u>

The Federal Lands Highways Program (FHLP) authorizations thru 2009 total $4.5 billion for Indian Reservation Roads (IRR), Park Roads and Parkway Programs (PRP, discussed in previous section), Public Lands Highways (discretionary and Forest Highways), and Refuge Roads programs. FLHP funds can be used for transportation planning, research, engineering, and construction of highways, roads, parkways and transit facilities within public lands, national parks, and Indian reservations. In addition, FLHP funds can be used as the State/local match for most types of Federal-aid highway funded projects. New eligible uses of Public Lands Highways funds include up to$20 million per year for maintenance of Forest Highways, $1 million per year for signage identifying public hunting and fishing access, and $10 million by the Secretary of Agriculture to facilitate the passage of aquatic species beneath roads in the National Forest System.

The FLHP is the most likely funding source for GRSM and includes:

1. FLHP Category I- 3R
2. FLHP Category I- 4R
3. FLHP Category II- Completion of Parkway Gaps Authority by Congress
4. FLHP Category III- Transportation Management Program (formally the Alternative Transportation Program)
5. FTA Alternative Transportation in Parks and Public Lands Program (ATPPL)

The Transportation Management Program (TMP) is the continuation of the interim Alternative Transportation Program, which served to support projects until the new alternative transportation (public transit and non-motorized transportation) program became well established. At this time, the NPS and FHWA are still considering what types of projects and activities are covered under Category III, and funding is limited. More information is available on the internet at: http://www.nps.gov/transportation/alt/prog-stra-plan.htm.

The new ATPPL provides for projects and activities that reduce the use of private automobiles by park visitors. The three early deployment projects for GRSM do not directly impact public transportation, but they could indirectly affect it. For example, real time traveler information might influence potential park visitors to use an alternate mode of travel such as the Gatlinburg trolley to the Sugarland Visitor Center. More information for this program can be found at: http://www.fta.dot.gov/funding/grants/grants_financing_6106.html.

Both the FLHP TMP and the FTA ATPPLP entail a periodic call for potential GRSM projects from the NPS Southeast Regional Office. Such project proposals would need to compete for funding. This GRSM ITS Plan should serve well in supporting ITS Project Proposals.

B. State and Local Sources

In April 2004 the US Environmental Protection Agency (EPA) designated the counties of Anderson, Blount, Jefferson, Knox, Loudon, Sevier and a portion of Cocke County within the Great Smoky Mountains National Park in non-attainment of the 8-hour standard for ground level ozone. As a result of the designation the Knoxville TPO has the authority to program Congestion Mitigation and Air Quality Program (CMAQ) funds in these counties. These funds are used in designated counties to fund transportation projects which reduce congestion and promote air quality improvements.

Several GRSM gateway communities in Tennessee, including Gatlinburg, Pigeon Forge and Sevierville, lie in the Sevier and Jefferson County sub-region of the Knoxville Regional ITS Architecture.

The GRSM is not part of a TPO area in North Carolina. The North Carolina Department of Transportation has established a Rural Planning Organization (RPO) structure whereby all areas outside the TPO have organized to provide systematic representation. The North Carolina GRSM gateway communities belong to the Southwest Commission (Western Region - 7 counties) RPO.

The North Carolina GRSM gateway communities, including Cherokee, Bryson City and Waynesville, are part of the Western Region rural ITS architecture of North Carolina.

It is through partnerships with the local gateway communities that GRSM has access to Federal, State, and local transportation funds. States and MPO recipients can use Federal-Aid funds to fund operational improvement projects for park roads and parkways. The various funding sources include:

Federal Level Funding:

- National Highway System (NHS)
- Surface Transportation System (STP)
- Bridge Replacement and Rehabilitation; This would not likely apply to the GRSM early deployment plan
- Congestion and Air Quality Improvement (CMAQ) for non-attainment and maintenance areas
- High Priority Projects (HPP) or Congressional Earmark/Demonstration Projects

State Level Funding:

- 1986 Roads Program – In 1986 the Tennessee State Legislation passed a pay-as-you go transportation improvement program where projects are funded via 4 cents per gallon of gasoline and 3 cents for other motor fuels.
- Motor Fuels Tax – This tax on motor fuels is approximately 22 cents per gallon and yields over $660 million per year with about 37 percent going to local municipalities and the remaining portion to TDOT projects or the State General Fund.

Local Level Funding:

All of the gateway communities can fund transportation projects through local funding, however funds are typically limited. In Blount County, Tennessee, which abuts GRSM on the south side near Cades Cove, getting a wheel tax referendum onto the ballet was recently defeated by County Commission. None of the gateway communities in Sevier County have a wheel tax and their budgets are limited. Some of those cities have used TIFs to fund transportation improvements, and on occasion, they have issued bonds.

There are three local transit systems near GRSM that receive FTA funding including:

- Gatlinburg Mass Transit
- Pigeon Forge Fun Time Trolley
- Cherokee Transit

These systems might be an avenue whereby GRSM could receive FTA or TDOT transit funds.

The Eastern Band of Cherokee Indians is also a viable funding source, in part because they are supported by the tourism industry and have a vested interest in the Harrahs Cherokee Casino. Tourism revenue in Cherokee depends on good vehicular access and many trips to the area originate in Gatlinburg. The only reasonable way to get from Gatlinburg to Cherokee is via Newfound Gap Road. These early deployment projects would provide the Cherokee tourist industry valuable information on road conditions in GRSM and especially on Newfound Gap Road.

C. SAFETEA-LU (Federal-aid Highway Programs)

SAFETEA-LU is the current overall transportation legislation in effect in the US. It was signed into law in August of 2005 covering a five year funding period through 2009. Following is discussion of several potential funding sources within SAFETEA-LU.

Title 23 states: "Cooperation of States, counties, or other local subdivisions may be accepted in construction and improvement, and any funds received from a State, county, or local subdivision shall be credited to appropriations available for the class of Federal lands highways to which such funds were contributed."

North Carolina, Tennessee or other recipients of Federal-aid dollars may apply for funding of GRSM ITS early deployment projects through Federal programs based on the unique transportation needs. Park projects should roll up into the State Transportation Improvement Program (STIP). FHLP funds can be used as the State match for Federal-aid funding. Potential Federal programs include the following:

<u>Transportation Systems Management and Operations</u> (Sections: 1201, 1808, 5101(a)(5), 5211, 5305, 5306, 5310(8)) – These sections amend title 23 so that transportation systems management and operations (TSM&O) programs and projects are integrated into and facilitated through the capital planning and construction processes. Eligibility for transportation systems management and operations is found in a number of programs, including:

<u>Real-Time System Management Information Program [1201]:</u>

- Establishes a new program aimed at providing in all States the ability to monitor, in real time, the traffic and travel conditions on major highways and to share that information to improve the operation of the highway system.
- Sharing information will improve the security of the surface transportation system, address congestion problems, support improved response to weather events, and facilitate national and regional traveler information.
- This program would result in a nationwide system of basic real-time information for managing and operating our surface transportation system; help identify longer range real-time highway and transit monitoring needs and develop plans and strategies for meeting those needs; and provide the capability and means to share that data with State and local governments, and the traveling public.
- North Carolina and Tennessee may use NHS and STP funds for planning and deployment of real-time monitoring elements that address travel from major highways to GRSM. The park may leverage this opportunity to tie in more specific park and park road information.

National Highway System:

- Continues eligibility for capital and operating costs for traffic monitoring, management, and control facilities and programs. [23 USC 103]
- U.S. 441 on the west into the park to Little River Road is designated on the National Highway System.
- U.S. 441 on the east into the park to the Blue Ridge Parkway is designated on the National Highway System.
- North Carolina and Tennessee may support park road improvement with NHS funds.

Transportation Planning: continues the provisions that:

- Allow the Secretary to provide funding to support adequate consideration of transportation systems management and operations, including ITS, within metropolitan and statewide planning processes.
- Requires the plans for metropolitan areas and States provide for the integrated management and operation of transportation systems that will function as an intermodal transportation system. One of the considerations of metropolitan and State planning processes for projects and strategies is the promotion of efficient system management and operation.
- The National ITS Architecture and Standards Rule (23 CFR Parts 655 and 940) requires that a regional ITS architecture be developed to guide the development of ITS projects. Section 940.9 states that "Provision should be made to include participation from the following agencies, as appropriate… … highway agencies; public safety agencies (e.g., police, fire, emergency/medical); transit operators; **Federal lands agencies**; … … to fully address regional ITS integration." (emphasis added). Thus the regional ITS architectures for both Tennessee and North Carolina are directed to include consideration of ITS for Federal Lands Highways that lie within GRSM. Regional architectures are to include the sequence of projects for implementation.

Intelligent Transportation System (ITS) Research:

ITS R&D priority areas include several transportation system management and operations elements, such as traffic management, incident management, freight management, road weather management, and traveler information. From funds authorized for ITS Research, $7 million is set-aside for each of fiscal years 2005-2009 for the continuation of ITS management and operations in the Interstate Route 95 corridor coalition region initiated under ISTEA. [5211]

Though not formally a part of SAFETEA-LU, the following USDOT initiatives have been focus areas of the department since 2004 (see http://www.its.dot.gov/newinit_index.htm). Potentially applicable categories are in bold.

- Cooperative Intersection Collision Avoidance Systems
- Electronic Freight Manifest
- **Emergency Transportation Operations**
- Integrated Corridor Management Systems
- Integrated Vehicle Based Safety Systems
- **Mobility Services for All Americans**
- **Nationwide Surface Transportation Weather Observing and Forecasting System – Clarus**
- **Next Generation 9-1-1**
- **Vehicle Infrastructure Integration (VII)**

II. POTENTIAL PRIVATE SOURCES OF PROJECT FUNDING

A. Private Entity Sources

GRSM should explore various private funding options and partnerships that create win-win circumstances for the local communities and visitors of the park. For example, there may be opportunities to partner with Harrahs Cherokee Casino or Dollywood. These two entities, along with GRSM, are likely to generate the highest number of trips per day and would benefit significantly from better traveler information within GRSM and the region. The Ripleys attractions in Gatlinburg may also have the wherewithal to partner with GRSM on disseminating better traveler information.

Communication companies would probably be interested in fiber optic through GRSM between Cherokee and Gatlinburg. Although this is a viable funding source, it has tradeoffs that GRSM might not be willing to or able accept.

B. Related Funding Categories

Transportation projects in Tennessee and North Carolina have been supported for many years with traditional sources of funding including federal-aid and conventional state and local resources such as motor fuel taxes, vehicle registration fees, sales taxes and other local option taxes. However, these traditional sources and the traditional NPS funding sources alone may not adequately fund the proposed projects.

GRSM may need to take advantage of innovative financing techniques, including public/private partnerships and new tools available on both the federal and state levels. This includes using a variety of available federal funds, private funds, park entrance fees, and other means. Under deed terms of GRSM, instituting park entrance fees would require legislative action by both the Tennessee Legislature and the US Congress.

Public Private Partnerships (P3) – Innovative Project Finance and Delivery

Traditional capital projects have been funded primarily through public funds or toll revenue. The private sector role has been as support to the DOTs in implementing these programs. Traditional ITS projects have followed a similar road. Public Private Partnerships involve some give and take on both sides. The sole reason for a private entity to be involved in any project is to make a profit. For ITS projects, this can be in the value of information and data. One reason for public sector involvement in P3 is typically because the government entity may lack the resources to implement a project, and it recognizes the value to immediate deployment. Some other reasons may include the following:

- Turning to the private sector to provide specialized management capacity for large and complex programs
- Enabling the delivery of new technology developed by private entities
- Drawing on private sector expertise in accessing and organizing the widest range of private sector financial resources
- Allowing for the reduction in the size of the public organization and the substitution of private sector resources and personnel

Design-Build

Design-build is a contracting method that combines two, usually separate services into a single contract. With design-build procurements, owners execute a single, fixed- fee contract for both architectural/engineering services and construction. Teams responding have both engineering services, and contractors/vendors included. The advantages are typically due to fast-tracking and total project cost savings. The costs are generally in the loss of oversight to ensure all public standards and needs are met. Presently, 34 states have authority to enter into design-build projects.

Section 1503 of SAFETEA-LU eliminates the $50 million floor on the size of contracts that can use design-build contracting without special approval. This may be a valuable provision making design-build more an option worth considering for GRSM ITS projects.

Design-Build-Finance-Operate

This funding option is not a likely option for GRSM. Design-Build-Finance-Operate (DBFO) is essentially a completely private sector approach to implementing transportation infrastructure, with the exception that the public agency retains ownership of the facility. The private sector is responsible for almost all aspects of the project. These projects are usually funded by direct user fees (tolls), lease payments, shadow tolls or vehicle registration fees. Future revenues are leveraged to issue bonds or other debt that provide funds for capital and project development costs. Public sector grants in the form of money or contributions in kind, (e.g. right-of-way) often supplement the project.

It can be noted that today unlike some other parks in the National Park System, GRSM does not have any concessionaire operators for transportation, food services or other park functions.

Build/Own/Operate

This funding option also is not a likely option for GRSM. Build-Own-Operate (BOO) allows a private company the right to develop, finance, design, build, own, operate, and maintain a transportation project. This approach is more common in the power and telecommunications. The private sector partner owns the project outright and retains the operating revenue risk and all of the surplus operating revenue in perpetuity.

III. INNOVATIVE FINANCING TOOLS

The following financing programs typically apply to States and political subdivisions. These do not seem to identify eligibility for other public authorities, and it is unclear from the information if such programs can in fact be considered for GRSM or other NPS sites. Further exploration between the NPS FLHP Coordinator and the Federal Lands Highway Office would be needed.

Grant Anticipation Revenue Vehicles (GARVEEs)

GARVEE bonds are state-issued, tax-exempt anticipation notes backed by future apportionments of federal-aid highway funds. General requirements for GARVEE financing are the project would already be eligible to receive federal-aid highway funds, has received final environmental clearance and has completed project design. GARVEEs are not a source of direct federal credit assistance, but rather a leveraging technique designed to assist states and other public authorities with bond financing of highway projects. GARVEES issued as of late 2005 are presented in **Figure 16**.

FHWA defines GARVEE eligible debt instruments as "any bond, note, certificate, mortgage, lease or other debt financing instrument issued by a public authority, the proceeds of which are used to fund a project eligible for assistance under Title 23, USC". GARVEE debt structure is a function of individual state laws and fiscal conditions. In addition to the eligibility requirements, GARVEE candidate projects also tend to have the following characteristics:

- They are large enough to merit borrowing rather than pay-as-you-go grant funding, with the costs of delay outweighing the costs of financing;
- They do not have access to a revenue stream (such as local taxes or tolls) and other forms of repayment (such as state appropriations) are not feasible; and
- The sponsors (generally state DOTs) are willing to reserve a portion of future year federal-aid highway funds to satisfy debt service requirements.

FIGURE 16. GARVEES ISSUED AS OF NOVEMBER 2005

Source: FHWA

State Infrastructure Banks (SIBs)

State Infrastructure Banks (SIBs) allow the use of federal funds for loans to transportation facilities and projects that are made on the state level. States enter into an agreement with the Secretary of the U.S. Department of Transportation to create a SIB and establish revolving funds using federal aid. SIBs allow a small amount of federal funding to leverage larger improvements and they can also be useful in attracting private investment. Borrowers include any public entity. Private companies and non-profit organizations are eligible but with some restrictions.

By the end of September 2006, the nation's SIBs had reached a major milestone, with the issuance of $6 billion in loans. For application to GRSM, the park would have to work closely with either Tennessee or North Carolina.

Pass-Through Financing, Availability Payment, or Shadow Tolls

These financing instruments involve state reimbursement of project costs to a contractor or concessionaire based on an agreement. This tool has not yet become as widespread in use as others, but they can be useful in the right circumstances.

Combined Innovative Finance Projects

GRSM can use, on a single project, various combinations of these funding sources.

Section G: Next Steps

This study was conducted to determine how ITS in and around GRSM could be implemented and operationally coordinated over a period of time. The Study results established a framework for the park. This study aimed to "link" both in-park and surrounding community ITS activities with other regional and statewide ITS activities in Tennessee and North Carolina. One of the major benefits of this effort has been that the plan process has brought forth a good deal more collaboration among park interests, both between Stakeholders and between park divisions themselves. One of the key next steps then is to keep this spirit of collaboration alive in pursuing implementation of individual projects. It is certain that there will be some controversy about aspects of some projects, given the fundamental debate between those who wish to preserve the park in as natural a state as possible and those who wish to spread the park's benefits to as many users as possible. Striking an appropriate balance requires a high level of continuing commitment to collaborative discussion and coordinated activity.

The results of the study are contained in this GRSM Strategic ITS Plan, which contains a great deal of information. There are numerous opportunities to utilize the information in this plan. Examples are general transportation and information-sharing improvement projects on which ITS initiatives can "piggy-back," such as road improvements that provide the chance to install communications conduit at low cost, or agency web-site development that could incorporate park condition information. The Technology Assessment presented in Appendix B will be of use when developing requirements and selecting devices to deploy. Both Appendix C and the ITS Architecture in Volume II identify communication channels and information sharing agreements necessary to assist GRSM in fulfilling the theme areas while improving transportation in the park. Because this effort has rigorously followed federal requirements for planning of ITS projects, it provides all the programmatic groundwork needed to quickly advance the project proposals through funding procurement, design and implementation.

It is important to note that this plan is intended to be a living document. Elements within the plan, such as the GRSM ITS Architecture, need to be updated as improvements are made or as GRSM ITS projects are implemented. As deployments are realized, the list of potential projects to deploy will need revision so that opportunities can be effectively utilized when they arise. In addition, the cost information in this plan is only valid for a period of time due to changing economic conditions.

Project implementation for the three selected Early Start projects will involve requirements/design and procurement document preparation, evaluation and selection of consultant/vendor, installation and integration, testing, and operational support. Many of the integration projects will require the same activities to fulfill the requirements identified in this plan. Planning projects will require procurement document development, consultant selection, assessment(s), and detailed project planning.

Appendix A –ITS Workshop Minutes – October 7&8, 2003

MEETING MINUTES

GREAT SMOKY MOUNTAINS INTELLIGENT TRANSPORTATION SYSTEM
STRATEGIC DEPLOYMENT PLAN

Meeting Description: ITS Workshop / Stakeholder Meeting #3

Date: October 07 & 08, 2003

Time: 8:30 AM each day

Location: Glenstone Lodge

Participants:

Name	Organization	E-mail Address
Steering Committee		
Shawn Benge	NPS	shawn_benge@nps.gov
Teresa Cantrell	NPS	teresa_cantrell@nps.gov
Dianne Flaugh	NPS	dianne_flaugh@nps.gov
Frank Corrado	FHWA	frank.corrado@fhwa.dot.gov
Mike Smart	FHWA	michael.cmart@fhwa.dot.gov
M.G.Habib	FHWA	m.habib@fhwa.dot.gov
Jeffrey VanNess	FHWA	jeffrey.vanness@fhwa.dot.gov
Martha Morecock	Wilbur Smith Associates	mmorecock@wilbursmith.com
Hollis Loveday	Wilbur Smith Associates	hloveday@wilbursmith.com
Vinit Deshpande	Wilbur Smith Associates	vdeshpande@wilbursmith.com
John Gould	Wilbur Smith Associates	jgould@wilbursmith.com
Frances Hall	Hall Communications	franhall2326@aol.com
Dawn Ford	Hall Communications	dfordtn@earthlink.net
Mike Conger	Knoxville TPO	mike.conger@knoxmpc.org
Kelley Segars	Knoxville TPO	kelley-segars@knoxmpc.org
Mark Best	TDOT	mark.best@state,tn.us
Reuben Moore	NCDOT	reubenmoore@dot.state.nc.us
Stakeholders		
David Ball	City of Gatlinburg	dball@ci.gatlinburg.tn.us
Karen Ballentine	NPS	karen_ballentine@nps.gov
Lynda Doucette	NPS	lynda_c_doucette@nps.gov
Jeff Cabe	Graham County, NC	jeff.cabe.comgr@ncmail.net
Kent Cave	NPS	kent_cave@nps.gov
Joe Dunn	City of Pigeon Forge	jdunn@cityofpigeonforge.com
Glenn Jones	Co. Commissioner Swain County NC	
Kathy Littlejohn	E. Band of Cherokee Nation	ctran@nc-cherokee.com
Larry Hartman	NPS	larry_hartmann@nps.gov
Gary Horne	NPS	gary_horne@nps.gov
Ned Long	E. Band of Cherokee Nation	nedlong@nc-cherokee.com
Scott Marine	Pigeon Forge Trolley System	smarine@cityofpigeonforge.com

Mark Miller	City of Pigeon Forge	mmiller@pigeonforge.com
Ken Mills	Swain County NC	kenmills@edc@yahoo.com
Calvin Murphy	E. Band of Cherokee Nation	cmurphy@nc-cherokee.com
Jim Northup	NPS	jim_northup@nps.gov
Buddy Parton	City of Gatlinburg	BParton20@aol.com
Paul Reynolds	City of Townsend	nreynol2@bellsouth.net
Benjamin T. Rose	E. Band of Cherokee Nation	erose@nc-cherokee.com
Curtis Thompson	E. Band of Cherokee Nation	curtthoma@nc-cherokee.com
Janet Whaley	City of Gatlinburg	jwhaley@cityofpigeonforge.com

On the first day Shawn Benge with the NPS welcomed everyone and thanked them for participating. He then described the purpose of the workshop. Shawn then introduced Martha Morecock who described the current stage of this ITS Strategic Process. Martha then introduced Steve Albert of the Western Transportation Institute (WTI).

Steve provided a brief overview of ITS as it relates to the NPS. Major topics included emergency services, traveler and tourist information, traffic management, rural transit and mobility, crash prevention and security, operation and maintenance, and surface transportation and weather.

Steve indicated that in the past the NPS has addressed 100 percent increased visitation since 1940 with the construction of new roads. These traditional solutions are not always appropriate today.

Travelers today visiting national parks don't care about jurisdictional boundaries. Moreover, they want information, both before and during their trip. They want the information to be timely and accurate. This information needs to be coordinated across all agencies and provide alternatives.

Steve indicated that institutional cooperation related to ITS in the National Parks must be the foundation of any system. Shawn Benge said that GRSM works together with gateway communities, but that a formal agreement regarding an ITS program is needed. Steve suggested Memoranda of Understanding (MOUs) between GRSM and the gateway communities. Frank Corrado noted that development of MOUs may be part of the Strategic Process.

Steve then divided the attendees into 2 teams. On the first day, each team was asked to identify transportation issues (their vision of ITS for GRSM) and to prioritize them. Each member of each group offered input to be recorded on a flip chart. Each member of each group was then given 5 small circle, or dot, stickers. Each member was asked to place one or more of the dots beside an item on the flip chart to indicate priority with high priority represented by a higher number of dots, and conversely, lower priority based on a smaller number of dots. After each team provided their vision of ITS in GRSM, the whole group discussed each team's transportation vision for improved transportation. The following are details of each team and their conclusions.

TEAM ONE
October 7
Facilitator: Steve Albert, WTI
Mike Smart, FHWA
M. Habib, FHWA
Kathy Littlejohn, Eastern Band Cherokee Nation (EBCN)
Vinit Despande, WSA
Mark Best, TDOT
Jim Northup NPS
Teresa Cantrell, NPS
Larry Hartmann, NPS
Scott Marine, Pigeon Forge Trolley System
Ned Long, Eastern Band Cherokee Nation
Gary Horne, NPS
Kent Cave, NPS
Benjamin Rose, Eastern Band Cherokee Nation

The team was asked to brainstorm the elements of the vision for ITS.

Prioritized Elements in Descending Order

9 dots - Solutions that educate visitors and enhance their experience in a way such that they want to protecting the natural environment and preserve resources
7 dots - Coordinate lobbying efforts
6 dots - Regional cooperation
4 dots - Accurate, timely and coordinated information sharing and dissemination
4 dots - Provide funding for community based transit
2 dots - Integrated regional transportation authority
2 dots - Coordinates transit system
1 dot - Enhance visitor experience regionally
1 dot - Provide infrastructure that enables safety

The team was then asked to list and prioritize challenges and opportunities associated with the vision.

Prioritized Challenges in Descending Order

19 dots - Lack of regional partnership, communication and coordination.

Challenges include:

Building trust
Creating a common vision
Different missions of involved parties
Identifying partners
Getting the right people together
Interagency communication
Sustaining long term interest
Organization structure

10 dots - Lack of funding
7 dots - Lack of integrated transportation and tourism service strategy

6 dots -	Need for resource protection including air and water quality
6 dots -	Lack of credible, consistent traveler information making it difficult to target messages to long distance visitors and provide non-conflicting information
4 dots -	Limited real time conditions including weather, accidents, animals, parking, congestion and elevation change
3 dots -	Identification information sharing opportunities and technologies between institutions.
2 dots -	Need for traffic management and enforcement
0 dots -	Lack of communication coverage

TEAM TWO
October 7
Facilitator: Martha Morecock WSA
Paul Reynolds, City of Townsend
Jeff Cabe, Graham County NC
Reuben Moore, NCDOT
David Ball, City of Gatlinburg
Dianne Flaugh, NPS
Mike Conger, Knoxville TPO
Lynda Doucette, NPS
Curtis Thompson, Eastern Band Cherokee Nation
Jeffrey VanNess, FHWA
Frank Corrado, FHWA
Calvin Murphy, Eastern Band Cherokee Nation
Buddy Parton, City of Gatlinburg

The team was asked to brainstorm the elements of the vision for ITS.

Prioritized Elements in Descending Order

8 dots -	Communicate on a larger level and communicate to visitors so they have a better experience. Related elements include: NC travel information system with the park information included on road conditions and traffic incidents, en-route information about road closures through a variety of mechanisms, and A current problem is having two telephone numbers, one in NC and one in TN to get road information.
8 dots -	A successful project that: creates partnerships, can be something that stakeholders believe was worthwhile, actually starts something, is performance based with accountability measurements, is customer oriented, looks at the larger picture with an end result of functions working well with each other, and has MOAs and MOUs to break down barriers and build trust among stakeholders.
7 dots -	Consistent messages between all entities in the region that include information to help visitors plan a trip. Improve communication between agencies and departments within agencies.

3 dots -	A plan that sets out in phases that can build on one another to get more support and not get bogged down.
3 dots -	Define region and identify stakeholders to be involved
2 dots -	Formation of organization of all gateway communities and counties so speak with a single voice
1 dot -	Reliable deployment of technology realizing it's important to know the client base and that not all visitors use technology.

The team was then asked to list and prioritize challenges and opportunities associated with the vision.

Prioritized Challenges in Descending Order

16 dots -	Lack of communication between departments in the park so employees outside Headquarters don't always have accurate information about road closings and between the park and gateway communities. Too much reliance on dispatcher who has many other functions. Need to determine most effective means for getting information out and ensuring accuracy.
12 dots -	Need for a traffic management education and communication system about using mass transit and educating the tourist regarding congested spots,
10 dots -	Need for a mass transportation system over the mountain between TN and NC.
6 dots -	The Park as it is organized cannot carry out modern transportation functions. There is no institutionalized group handling operations. Need an internal cross functional group to manage transportation.
2 dots -	Ineffective highway signs directing visitors to the park on the NC side. Not specific enough.
2 dots -	Lack of communication equipment in the Park including limited radio system due to many dead spots in the park, lack of e-mail at NC visitor's center and no internet network in remote sites.
2 dots -	Accident response if an incident blocks the road. Response people can't get through, the road is blocked for a long time, people cannot get to the hospital quickly and can't always use a helicopter
2 dots -	Visitors need positive experience even if road is closed so they will come back again. Need to communicate with visitors in a positive manner directing them to other activities without upsetting gateway communities.
2 dots -	Cades Cove traffic and a need to educate visitors about best time to go through and alternative activities when Cove is busy. Lack of sharing information about what is happening in the region.
1 dot -	Traffic management encouraging slow cars to use pull outs.
1 dot -	Finite system of roads with numbers of visitors continuing to grow Roads limit mobility and access
1 dot -	Dealing with daily movement of traffic and weather
1 dot -	During tunnel work there is a need to balance road closures so visitors don't sit too long. Need to balance maintenance needs with what is happening in the area at certain times of the year. Meet traveler's expectations and don't close a lane for utility work during peak season.
1 dot -	Need for Cherokee tribe to play vital role in system
0 dots -	Better management of traffic flow

0 dots - Telling travelers what's out there. What works in urban area doesn't always work in rural setting.
0 dots - Lack of alternative routes
0 dots - Traffic travel time
0 dots - Need to educate tourist about when to come
0 dots - Need an assessment of what is already on the table but not utilized

On the second day, Steve Albert reviewed the results of Day 1 and provided some background information relevant to the Day 2 activities. Steve suggested that WSA develop a vision statement that reflects the attendees vision of GRSM ITS. Steve then reviewed the types of projects that could be implemented in GRSM. Once again the 2 teams reconvened and were charged with 2 tasks: 1) identifying current transportation projects and 2) identifying ITS strategies. After lunch, the ITS strategies of both teams were merged together and ranked by all participants using the dot sticker system. A more detailed summary of Day 2 activities is provided in the following sections.

Results of Day 1:

VISION ELEMENTS (Top 3)	
Team One	Team Two
• Provide solutions that educate visitors and enhance their experience in a way such that they want to (are more willing to) protect the natural environment.	• Provide consistent messages between all entities in the region so the visitor has a positive experience.
• Provide a coordinated lobbying effort	• Create a successful project that creates partnerships, starts regional thinking in terms of strategies, and focuses on performance-based and customer-oriented ITS strategies.
• Enhance regional cooperation	• Develop a plan that moves forward in phases that build on one another so it doesn't bog down but gathers support.

PROBLEM IDENTIFICATION (Top 5)	
Team One	Team Two
• Lack of regional partnership, communication, and coordination	• Lack of accurate and consistent communication about road closures within park and to gateway communities
• Lack of funding	• Need for a mass transportation system with a park and ride facility between Gatlinburg and Cherokee
• Lack of integrated transportation and tourism services strategies	• Need for education of tourists regarding congested areas (and alternate routes)
• Limited real-time condition information	• Lack of an institutionalized group within the park handling traffic management
• Lack of credible and consistent traveler information	• Ineffective signage leading tourists to the park. (Signs don't always provide the most direct routes or provide enough information.)
• Need for resource protection (tie)	

TEAM ONE
October 8
<u>Facilitator: Steve Albert, WTI</u>
Mike Smart, FHWA
M. Habib, FHWA
Kathy Littlejohn, Eastern Band Cherokee Nation
Vinit Despande, WSA
Mark Best, TDOT
Jim Northup NPS
Teresa Cantrell, NPS
Larry Hartmann, NPS
Glenn Jones, Swain County
Scott Marine, Pigeon Forge Trolley System
Ned Long, Eastern Band Cherokee Nation

The team was asked to identify existing and planned projects, future/wish list projects, and data collection systems in their geographic area. Notes contained on the flip charts follows:

<u>Swain County NC</u>
Visitor information center
E911 system upgrade

<u>Cherokee NC</u>
Demand responsive service depending on availability
Town shuttle
Trained guide service
Excursions in Cherokee
Driver PDA (future transit)
Fiber optics communication (wish list)
PED walkway - park and ride
Transit service downtown
Cross county transit service
Bi-state shuttle (NC and TN) (wish list)

<u>Pigeon Forge</u>
Next bus selective locations
Automated passenger counters/EPS in future
AVL system (wish list)
Traffic signal upgrade
Fiber optics communication in Pigeon Forge and Sevierville
Pullout stops

National Park
New narrow band digital radio system (enhance communication within the park including variable message signs)
Cades Cove planning process
North Shore Road planning
New search and rescue vehicle
Public safety - lighting, warning system, speed control on the Spur
VMS signs at entrance
BRT Study
Air quality monitoring stations
Major attraction - zoo/educational (wish list)
Real time web (wish list)

TDOT
Cumberland Gap Tunnel project
Knoxville ITS project
511 Initiative

The team was then asked to identify and prioritize ITS Strategies for the region

Prioritized Strategies in Descending Order

17 dots -	Create a regional transportation management center that includes the states, counties, Cherokee Nation and Park.
15 dots -	Develop a system to share information that is a central repository for sharing with a dedicated staff with "PULSE" devices to ensure real time conditions.
14 dots -	Develop a system to collect real time current /forecasted data that can be shared about weather and transit. Use radar detection, loop detectors, probes and closed circuit television cameras (CCTV), road/ weather information systems (RWIS), vehicle diagnosis, fare collection and passenger counts.
8 dots -	Continue dialogue for regional projects and coordination. Identify champions for steering committee and create a governing board
6 dots -	Implement a traveler information system that addresses unique visitor needs and preferences in a variety of locations, such as changeable message sign (CMS) placed at intercept points, and/or a TV station in Gatlinburg and Cherokee and kiosks
2 dots -	Develop a resource education program utilizing existing information systems such as the media and web
0 dots -	Secure a specific peer to peer program or Scanning tour to learn from others experience and apply lessons learned to region
0 dots -	Create a regional coordinated transit system service that meets Gateway and park demands.
0 dots -	Coordinate a regional transportation safety effort.
0 dots -	Coordinate lobbying efforts to secure money.

TEAM TWO
October 8
Facilitator: Chris Strong, WTI
Paul Reynolds, City of Townsend
Jeff Cabe, Graham County NC
Reuben Moore, NCDOT
David Ball, City of Gatlinburg
Dianne Flaugh, NPS
Kelley Segars, Knoxville TPO
Ken Mills, Swain County NC
Janet Whaley, City of Gatlinburg
Lynda Doucette, NPS
Marc Miller, City of Pigeon Forge
Martha Morecock, WSA
Curtis Thompson, Eastern Band Cherokee Nation
Jeffrey VanNess, FHWA
Frank Corrado, FHWA
Shawn Benge, NPS

The team was asked to identify existing and planned projects and data collection systems in their geographic area.

National Park
Visitor satisfaction system
Park weather information
Traffic counts
Accident data
Radio upgrade - digital instead of analog
Two variable message signs
7 or 8 traveler information systems (TIS, short-range AM radio broadcast system) although all don't work

Gatlinburg
Traffic counts
ITS system
Early warning flood system

NCDOT
Incident management patrol route
I-40 overhead changeable message signs
Radio messages
Real time speed warning signs specifically for trucks and for other messages
Daily traffic counts
Fog detection system
Website with travel information such as weather and construction conditions
Road counter at Deep Creek entrance to the park
Variable message signs at Asheville and Newport

Pigeon Forge
Permanent TDOT traffic counter at south end of city

Sevier County
Sevier County Transportation Board is regional partnership charged with managing transportation projects for county.
Pigeon Forge and Gatlinburg working on a traffic management system for trolleys that will eventually be county wide. Next bus system; GPS locators on trolleys.

TDOT
ITS on I-40
Instant management patrol

Cherokee, NC
Trip system to count rides and calculate demand for mass transit system
Crash data

Road Projects
Corridor K in NC
Widening 321 in Gatlinburg
U.S. 19
Tow String Bridge in Cherokee
Exits in Pigeon Forge to Dollywood
Foothills Parkway link

The team was then asked to identify and prioritize ITS Strategies for the region

Prioritized Strategies in Descending Order

12 dots -	Kiosks to include: real time traffic information, alternative activities, routing choices and tourist information
8 dots -	Signage to include: better signage at key areas of the park, variable message signs, more specific way finding signs especially on the NC side of the mountain, more effective placement, signs with emergency telephone numbers, signs indicating travel times, signs updated by automation, location and mile markers within park, mile markers on park maps , vehicle locators and signs for park and ride, and signs that are easier are see and read
6 dots -	511 System to include: information on weather, emergency situations, road closures, and kiosk locations

5 dots - Data collection systems to include:
radios in park vehicles for dispatch,
law enforcement in park monitoring local channels,
centralized county dispatch,
911 systems,
media,
CBs and police band radio,
cameras monitoring traffic,
webcams in park and other locations in Gateway cities and highway locations,
field sensors such as traffic loops, environmental stations etc,
weather stations that don't have to be checked by people to collect data on visibility, pavement conditions and weather conditions,
delay times at places such as Cades Cove, and
stream gauges accessed via the web

5 dots - Include park in County transit planning to coordinate transit

4 dots - Develop partnerships between park and gateway communities to initiate projects such as a county installing a weather station in the Park that would help both parties.

4 dots - Build visitor center on NC side to serve the three areas of park, Cherokee and county and include a park and ride.

1 dot - Separate website

1 dot - Radio guide or cassettes for Cades Cove

1 dot - Mapping of radio coverage with model for installing more effective radio coverage in park

0 dots - Assess where traffic management center would fall in park structure and how it would evolve.

0 dots - Central control devices

0 dots - Gateway community website with details on transit.

0 dots - Develop itinerary planners

<u>Strategy Wrap-up Combining Highest Priorities of Both Teams</u>

1. System to share both centralized and real time information (15) using kiosks (12) 511 (6) and a new visitor center to provide travel options (4)

2. System to collect data that is relevant, current and forecasted (14)

3. Regional Transportation Management Center (17)
   Continue dialogue for partnerships (8)
   Develop partnerships with the gateway communities (4)
   Include park in transit planning in the counties (5)

4. Improve signage (8)

Input on Objectives

The Workshop attendees were requested to provide input on the list of 8 objectives identified for the project to date. Input received will be shared with the Steering Committee members for consideration. Input received:

- Include location reference (identify project boundaries) in objectives
- Include intra-agency communications as a separate objective
- Include an objective that reflects the heart of visitor appreciation.

Next stakeholder Meeting

The date of the next Stakeholder meeting was not discussed at the Workshop.

PLEASE NOTE THAT THE NEXT STAKEHOLDER MEETING IS SCHEDULED FOR DECEMBER 16TH AT 1:30 PM IN NORTH CAROLINA. (There will not be a meeting held on 11/19.) **Information regarding the next meeting will be forthcoming.**

Appendix B - Technology Options & Assessment

Section I	GRSM ITS TECHNOLOGY ASSESSMENT
Section II	GRSM ELECTRICAL AND COMMUNICATIONS REQUIREMENTS

I. GRSM ITS TECHNOLOGY ASSESSMENT

In support of the output of the ITS Project Concept priority listing and the information in the GRSM-Centric ITS Architecture, applicable technologies have been identified. Potential technologies for GRSM consideration are presented for those Project Concepts designated as high priority for deployment. The Project Concept number was an identifier during the project, thus the concepts listed are not in sequential order because middle term and long term concepts are not included. Project Concepts 5, 12 and 13, denoted by *, are planning efforts.

For every ITS technology considered for deployment in GRSM, there is an issue of connecting the technology to power and communications back to a central location. Technologies cannot function without power and communications. So, in addition to the technology assessment, a discussion and recommendations are presented regarding electrical power and data-communication requirements for longer-term ITS deployments in GRSM.

The ultimate decision as to which technologies are deployed within the park lies with GRSM management.

Project Concept 1

Enhanced Wide-Area Communication System

The Enhanced Wide-area Communication System focuses on strengthening communications capabilities throughout the Great Smoky Mountains (GRSM) region to facilitate ITS deployment. The communications infrastructure forms the backbone of variety of ITS projects/applications to be deployed in the park in coming years. An intelligent transportation system is comprised of many elements – field components such as variable message signs (VMS), detector stations, ramp meters, and Closed Circuit Television (CCTV) cameras; central equipment such as computers, workstations and monitors; and the human element (i.e., system operators and maintenance personnel). For the system to function properly, it will be necessary for each of these components to exchange information efficiently and effectively with other system components. It is the communications network that provides the connecting link for information between system elements.

For short term purposes, GRSM region communication needs are focused around better communications for emergency and incident management, and maintenance/construction information sharing. In long term, the communication infrastructure will serve as a primary asset for variety of ITS applications deployment and hence the park authorities will have to investigate more advanced and robust communications infrastructure. To that effect, this technology assessment for enhanced wide-area communications system will focus in detail on different types, components, and technologies used for ITS deployment. As GRSM is currently deploying a two-way radio system, this information is being presented for future consideration – if the need arises. State-of-the-art communication frameworks will be described along with criteria for the communications media selection.

Technology Description: An area wide communications system can be designed using either hard-wired or wireless communication media. The most important factor in communication system design is the scope (coverage area or connection requirements) and the objective (planned ITS deployments) for the proposed communication system. It is realized that the communications requirements for GRSM region may not be as advanced or complex as for an urban TMC; however, at the same time, are challenged by the mountainous topography of the region. The following are different technologies used in typical communication systems:

Hardwire technologies include:

- Cable (Twisted pair, Coaxial, and Fiber Optic)
- Lease telephone lines (Voice grade, Digital communications such as T1 lines)
- Switched Telecommunication services (Dial-up wireline)
- Cable TV providers

Wireless Communications include:

- Radio networks
- Spread spectrum radio
- Point to point microwave
- Air path optics

Depending on the need of the system, the designer can consider some of the advantages and disadvantages associated with each communication option:

	Advantages	Disadvantages
Hardwire:	• Network may already be in place	• Network may not be in place
	• System redundancy often built in	• May be expensive to install in remote locations
	• If lease lines, no maintenance	• Relatively simple design compared to Wireless
	• Very reliable	• May require repeaters
	• Large bandwidths available	
Wireless:	• No need for physical medium	• Less reliable
	• Lower installation cost	• Relatively complex design compared to Hardwire
	• Easily spans natural barriers	• Limited choice of operating frequencies
	• Provides communications where ROW is not available	• Line of sight constraints for some technologies (900 MHz, Microwave, Spread spectrum Radio
	• Flexible implementation	• Limited bandwidth
	• Commercial off-the-shelf equipment available	• Monthly cost for cellular service
		• May require repeaters

Wireless communications can be used for remote sites where Plain Old Telephone System (POTS) or hardwire connections are not available or cost effective to install. The following table depicts different available options for communications infrastructure:

Comparisons of specific communications technologies.

Technology	Description	Advantages	Disadvantages
Fiber Optics	Fiber optics lines are installed in underground conduits.	• Very high data capacity • Video capability • Excellent noise immunity • High Reliability • Proven Status	• Complex to maintain • Conduit or overhead wiring required • High cost to purchase and install – reasonable cost if leased
Leased Lines	Telephone communication lines can be leased for transportation information	• Maintenance responsibility of owner, not GRSM • Proven Status	• Not available in GRSM • Moderate Reliabilities
Twisted Pair Cable	Twisted pair cable is used for communication purpose	• Easy to maintain • Least expensive • High Reliability • Proven Status	• Limited bandwith • Minimal video capability
Spread Spectrum Radio	Spread Spectrum Radio is part of the latest available technology for data transfer. Using the 900 MHz and 2.4 GHz frequency bands for communications, Spread Spectrum Radio gets its name from what it does: it spreads out the signal over a group of frequencies, thus making the signals extra-resistant to interference.	• No physical connection required • No FCC license required • Low potential for being interfered with or being interfered by other users • Easy to install (noise immunity)	• Complex to maintain • Line of sight required • Limited video capability • Moderate reliability in GRSM
Microwave Radio	Traffic control applications have used microwave links primarily as a communications trunk between offices and/or remote work centers carrying voice and data.	• No physical connection required • High bandwith • Video capability	• Complex to maintain • FCC license required • Line of sight required • Moderate reliability in GRSM

Technology	Description	Advantages	Disadvantages
Satellite		• No physical connection required • Cost independent of distance – ideal for long distance transmissions • Has video capability	• Complex to maintain • High monthly leasing cost • Large antenna required at each site • Moderate reliability in GRSM

Recommendations – A new two-way communication system is currently being deployed in GRSM.

Project Concept 2

Maintenance and Work-Zone Related Advanced Warning System

Maintenance and work zone areas can be dangerous to the workers, visitors and pedestrians passing through or near, and motorists traveling through these areas. This issue is further complicated by the GRSM park regional topography; mountainous roads with sharp curves, scenic view distractions, little to no shoulder widths, and driver expectations for a non-congested driving experience. Providing advanced information about work-zone areas can improve safety and help drivers make more informed decisions while planning in-park activities. This Project Concept discusses several ways of providing advanced warning information to park visitors.

Technology Description: This Project Concept involves several technologies that can assist in provision of advanced warning information about work-zone related activities. Specifically, these technologies involve traveler information services (ATIS), Highway Advisory Radio (HAR), Portable Changeable Message Signs (PCMS), and use of portable Speed Detection (PSD) systems. While ATIS and HAR will be discussed in greater details under Project Concepts 3 and 9, this technology assessment section focuses on PCMS and PSD systems.

Portable Changeable Message Sign (PCMS): A PCMS is a traffic control device that is capable of displaying a variety of messages to inform motorists of unusual driving conditions. This capability is achieved through elements on the face of the sign that can be activated to form letters or symbols. The message is limited by the size of the sign (usually three lines with eight characters per line). A PCMS is housed on a trailer or on a truck bed and can be deployed quickly for meeting the temporary requirements frequently found in work zones or accident areas.

Currently, PCMS can be deployed using two different technologies as shown in the table below:

Technology	Description	Advantages	Disadvantages
Flip Disk	This technology utilizes a system of small circular, square, or rectangular disks, individually rotating or flipping to form characters on the PCMS. Each disk has reflective material on one side that, when "flipped", is exposed to form the message. This PCMS type requires external illumination for nighttime viewing but the message remains in the event of a power disruption. This can be potentially positive or negative depending on the length of the power disruption. In the short term, your current (relevant) message will continue to be displayed, but in the event that the power disruption is longer than the usefulness of the message, the message displayed will be incorrect.	• Proven technology • Low power requirements • Provides a shape legible message • Can still utilize sign if light source fails • High reliability	• More moving parts leads to additional maintenance • Reflective disk surfaces can become sun-bleached over time • Not very visible during low level light conditions at long distances
LED	Light Emitting Diode (LED) technology utilizes clusters of solid-state diodes that form a single pixel. When voltage is applied, each diode glows. By turning voltage on or off, each pixel cluster is manipulated into forming the characters or pattern of the displayed message. Back up power is required in the cabinet to maintain the displayed message in the event of a power disruption.	• Visibility is good under most lighting conditions • Fewer moving parts require less maintenance • LED are rated for 100,000 hours of service • Proven technology	• Smaller cone of vision reduces message legibility at close distances • Diodes can be sensitive to heat • Moderate reliability • Requires continuous power supply

Portable Speed Detection (PSD): Portable Speed Detection signs are equipped with either radar or laser or combination technology for speed detection. PSD systems can be installed on vehicles, trailers, roadside stands, etc. and are used to inform drivers about operating speeds on a roadway to promote improved speed limit compliance. This is very helpful in work-zone areas to promote speed limit compliance for lower speed limits during construction and maintenance activities as spending in work-zones can be dangerous and life threatening. The following table depicts PSD system technology options:

Technology	Description	Advantages	Disadvantages
Radar	This technology uses Radio Detection and Ranging technology to monitor traffic speeds. This is based on radio frequency transmission and its return from the objective.	• Proven technology	• Beam is deflected and bounced from smaller objects • Not efficient in congested areas • Moderate reliability
Laser	This technology uses infra-red light beam to measure the automobile speeds. The automobile speeds are measured by time taken for laser beams to travel to and from the vehicle	• Proven technology • Improved accuracy over RADAR • Good performance in congested conditions • High reliability	• Smaller cone of vision reduces message legibility at close distances • Diodes can be sensitive to heat.

Recommendations – When deployed consider using LED portable message signs and Laser for the portable speed detectors.

Project Concept 3

Improved Real-Time Traffic Information Services (ATIS central database)

Providing near real-time information regarding roadway, parking and weather condition information in GRSM is a complex task and will require extensive coordination within park divisions and gateway communities. The focus of this project is to collect, process, and distribute multimodal traveler information from multiple sources. The objective of this Project Concept is to form a central data clearinghouse for the GRSM region to achieve regional traveler information service. In many ways, this Project Concept goes beyond just the GRSM jurisdictional and organizational boundaries; however, mentioning this project in this architecture effort provides a starting point for regional coordination.

Technology Description: A regional traveler information database requires extensive data collection, processing, and distribution capabilities (collect the data, make sense of it, and share the resulting information). Reliable communications infrastructure is necessary for such a clearinghouse. As evident from this general description about objective and intent of this Project Concept, several ITS technologies along with communication infrastructure are presented in Project Concept 1, 4, and 5 to serve as building blocks for a regional information clearinghouse. Project Concept 1 (Enhanced Wide Area Communications) is the backbone for data collection and information dissemination. Project Concept 4 (Improved Traffic Monitoring and Detection) collects the data. And Project Concept 5 (ITS Communications and Power Needs) addresses powering field devices and overall communications.

The regional central database for traveler information requires a central operations center or information management database that can collect, process, and distribute multimodal transportation data collected from several different agencies. GRSM may not be in a position to do this for the various service providers, but GRSM can collect information from GRSM devices in one central location. If all (or most) GRSM devices are collected at one central location in one system, it enables other service providers relatively easy access to access and/or distribute GRSM information on their system(s).

A data processing system has several responsibilities – to process, manage, and determine quality of data in the system. Central processing typically requires custom software to perform all responsibilities with the data (quality check, processing, etc.) For GRSM purposes, it is important to identify where data will be sent. This initially means to determine a physical location to receive field data. The physical location may need to (at first) accommodate several computers – which means that it is desirable to have at this location within the park: adequate power supply, physical space to accommodate an appropriate number of computers and workstations, adequate heating and cooling systems, and necessary communications access.

Central hardware components consist of at least one server which will receive field data and share it with GRSM staff on a workstation. The workstation will require development of a graphical user interface (GUI) to display the data received in a useful, user-friendly manner. The good news is that most field components come with software that performs these functions. When several field elements information is being received at the central database, and the information requires much effort to view the information in a logical manner, and/or the information received is becoming burdensome on those GRSM staff that are using the information, then it is time to consider acquisition of custom-tailored software to compile the various field elements' systems into one system.

Over time, as the GRSM continues to expand its ITS functionality, more servers will be added – for various devices (CCTV, DMS, HAR, gates, RWIS, etc.), to direct communications among the devices, and to provide greater functionality (such as incident management). The good news is that one central database can be used to accomplish several services such as traveler information, traffic and access management, emergency management, inclement weather, etc.

Several states have deployed information management systems that collect and compile incident information, traffic images and counts, maintenance and construction plans, work zone information, transit service details, etc. Such information is pushed into the regional clearinghouse by different agencies that are involved in operations and collection of useful transportation traveler information. The information pushed in to the central database is then distributed using various methods such as regional 511, agency websites, et cetera. GRSM will be able to participate in the other service providers systems with minimal manpower needs once the central database is operational. And, over time, GRSM will be able to receive and benefit from information received from other service providers' systems (such as transit AVL information when the vehicles are on or near park roads, incident management information that may impact GRSM roads, etc.)

Recommendations – GRSM to determine where to physically locate ITS computers. Utilize ITS device software on ITS computers for the short-term time frame. Consider customized software in the medium- to long-term timeframes.

Project Concept 4

Improved Traffic Monitoring and Detection

Without appropriate data collection, most ITS technologies will not have useful information to process or distribute. Data collection to some degree or the other is involved in most if not all ITS technologies. Reliable and effective data collection may be the most important advanced technology available.

Data collected can consist of volume (number of vehicles passing a point), occupancy (the amount of time a vehicle is within the detection zone), speed, and vehicle classification data (length, weight, number of axles, etc.). Detectors may only collect one lane of roadway per detector or several lanes per detector. Maturity, life cycle, and reliability of these technologies varies. Mounting criteria for the detectors, along with power and communication needs also influence which type of detector may be used.

Technology Description: Vehicle detector stations collect real time data on roadway traffic flow. There are several technologies that may be utilized for data collection depending on the environment and the type of data needed to be collected.

Inductive Loop: Inductive-loop detectors are the most extensively utilized detectors in the United States and around the world. They provide data on volume, speed, and density (occupancy). The technology consists of a loop wire of one or more turns embedded in the pavement and connected to an electronic amplifier (located in the controller cabinet). This detector identifies the presence or passage of a vehicle.

Radar/Microwave: This detector is not pavement-intrusive and is commonly used to monitor vehicle speeds for law enforcement and traffic management applications. Some advanced radar/microwave detectors can also be used as presence detectors. Because they use electromagnetic energy, radar/microwave sensors are typically unaffected by weather conditions, especially when measurements are made from a short distance. They can also be used for both day and night operations. Radar/microwave systems can provide volume, speed, occupancy, and presence detection.

Ultrasonic: These detectors (e.g., smartsonic) are passive acoustic sensors and automated-signal and information-processing systems that listen (no energy is radiated by the system) for the noise generated by stationary or moving vehicles in a detection zone on the roadway. Only those vehicle sounds from within a specific detection zone are retained. Sounds from locations outside the detection zone (such as an adjacent lane) are severely attenuated and are ignored. The detection process for vehicle sound energy is analogous to the way the metal in vehicles is detected as those vehicles pass over a loop. It is an overhead-mounted system with limited side mount. Ultrasonic detection fully emulates loop-output signals, and thus requiring no modification to existing system hardware or software. Ultrasonic systems can provide volume, speed, occupancy, presence, and classification data.

Infrared: There are two types of infrared detectors: active and passive. *Active infrared detectors* focus a narrow beam of energy onto an infrared-sensitive cell, and vehicles are detected when they pass through the beam, interrupting the signal. These detectors can be used either as presence or pulse detectors. Detector performance can be affected by weather conditions (fog, rain, snow) causing inconsistent beam patterns. *Passive infrared detectors* do not transmit energy, but measure the amount of energy emitted by objects in their field of view. Infrared detection systems can provide volume, speed, occupancy, presence, and classification data.

<u>Video Image Processing:</u> With video image processing, cameras provide images that are used by a video processor to emulate traffic data. It is possible to define multiple detection locations within the camera viewing area. These "pseudo detectors" are not fixed, but may be moved by the operator if desired. The type of signal processing algorithm used by the image processor dictates the type of data obtainable by the system. These systems can provide volume, occupancy, and presence detection. In more advanced systems, individual vehicles are tracked as they pass through the field of view, allowing identification of speed, vehicle classifications and travel times in the detection zone. Most processing algorithms have been optimized to compensate for shadows, illumination changes, and reflections.

<u>Closed Circuit Television (CCTV):</u> CCTV systems have been used for many years in the United States and around the world to provide visual surveillance of the freeway system. *Fixed location* CCTV systems include video cameras that are permanently mounted either on existing structures or on specially installed camera poles. This type of system consists of various components, including the following:

- Video camera unit
- Mounting structure (existing or installed)
- Controller cabinet housing the control equipment
- Communication system connecting camera to control center
- Video monitors and camera controls located in control center

Video images from cameras may be transmitted to a control center using either full motion video or compressed video. Full motion video allows real-time video to be transmitted to the control center. Real-time video is typically transmitted at a rate of 30 frames per second. This transmission type results in no information loss; however, it requires a wide communication bandwidth, such as that provided by coaxial cable or fiber optic cable.

Compressed video is an attractive option when it is not feasible to install the communication medium required for full motion video. An advantage of compressed video transmission is that video data can be transmitted over conventional telephone lines and cellular channels.

With compressed video techniques, transmission rates of 8 to 10 frames per second are possible. Because some information is lost between picture frames, the resulting image appears slightly "jerky." The image, however, is adequate for monitoring freeway operations. A compressed video system typically includes the following:

- Compression and decompression (codec) computer for each camera/monitor link
- Appropriate software
- Communications medium (typically a leased ISDN [Integrated Service Digital Network] line).

Standard cameras, monitors, and control hardware can be used, and therefore, can be reused if the communications medium is upgraded to allow for full motion video transmission. This is a manual type of detection, requiring an operator to view the video feed.

Acadia National Park experienced detector problems due to slow moving traffic (inherent in numerous National Parks), standing, and centerline crossing vehicles are not accurately detected. Loops to be used to count vehicles in the NPS environment need additional considerations. It is hoped that more information will be available from the Acadia experience.

Comparisons of different traffic detection technologies:

	Description	Advantages	Disadvantages
Loop Detectors	In this technology, vehicle passage cuts magnetic lines of flux generated around the loop. Resulting inductance change is detected and transmitted to an amplifying circuit.	• *Size and shape of detection zone can easily be set by Size of Loop* • Excellent presence detector • Capable of measuring all traffic parameters; • Relatively easy to install • Capable of detecting small vehicles • Wide range of applications • Provides basic traffic parameters • Proven Status	• Requires saw cutting of pavement • Installation requires closing of traffic lane or lanes for short periods of time • Detectors are subject to traffic stresses • Detectors are subject to damage and dislocation by road traffic or roadway equipment such as sweepers and snow plows. • Moderate reliability
Radar/Microwave	Passage of vehicle reflects microwaves back to antenna. May use Doppler principle as well as other techniques.	• May not necessitate closing of traffic lanes to install • Non-pavement or roadway invasive • Generally insensitive to weather conditions • Provides day and night operation • Proven Status	• Antenna alignment required • Requires FCC license for operation and maintenance • May lock on to the strongest signal (e.g., large truck) • Susceptible to interference from other devices operating at the same frequency • Moderate reliability

	Description	Advantages	Disadvantages
Sonic	In this technology, detector emits burst of ultrasonic energy at a rate of approximately 12 to 30 times per second; detects reflected ultrasonic pulse. (No information was discovered regarding sonic impact on wildlife.)	• May not necessitate closing of traffic lanes to install • Can be used at locations with unstable pavement • Can classify vehicle by height • Non-pavement or roadway invasive • Completely passive • Provides day and night operation • Proven Status	• Low Pulse Repetition Frequency (PRF) limits accuracy of occupancy and speed • May be difficult to get complete lane coverage and avoid adjacent lane detection • May be sensitive to temperature variations • Cannot be used in certain high wall locations • Relatively new technology for traffic surveillance • Environmental conditions such as winds, heavy snowfall, and rain may inhibit the propagation of sound waves. • May impact GRSM Soundscape policy – however, this has not yet been determined. • Moderate reliability
Infrared	A measure of energy is used to determine when an vehicle has entered the detector field – either passively (detection occurs when vehicle enters the field) or actively (a narrow beam of energy is focused and when the beam is broken by a vehicle detection occurs)	• Provides day and night operation • Provides most basic traffic parameters • Passive detectors can be used for strategic loop replacement • Proven status	• Operation affected by precipitation such as rain or fog • Difficulty in maintaining alignment on vibrating structures • Susceptible to sudden changes in background radiation due to rain or clouds • Some surfaces such as windshields and black metal and plastic car bodies are poor reflectors. • Moderate to low reliability for GRSM

	Description	Advantages	Disadvantages
Video Image Processing	Video cameras transmit their images to a processor; processor detects vehicles crossing line drawn across lane by analyzing image pixels	• Provides wide-area detection • Can provide traffic information beyond capability of spot detectors • Location or addition of detector zones can be easily done on the PC • High reliability • Proven status	• May be relatively expensive for simple applications • Subject to phenomenological error sources such as weather, shadows, occlusion and background lighting • May require significant processing power and a large communication bandwidth.

Recommendations – determined on a case-by-case basis. Recommendation depends on ITS device, use, and location within the park.

Project Concept 5

ITS Communications and Power Needs Assessment*

In order to support the various ITS systems identified in the various Project Concepts, a variety of electrical power sources and means of communication are presented. Existing power and communications within GRSM are a mix of public utilities and NPS-owned facilities. Other means include a propane generator at the Cable Mill area in Cades Cove to supply electric power and the Great Smoky Mountain Association uses a satellite telephone at the Cable Mill area to facilitate the operation of its bookstore (credit card purchases). Typically, the locations close to the park boundary have public utilities available, while locations deeper within the park use NPS facilities. These NPS facilities include battery and solar power and cell phone communication.

In order to provide power and communication to ITS devices located away from the park boundaries (inside the park) power and communication need to be supplied to these devices. In the short term, it may be possible to provide power through battery banks and solar power and communications through the use of cell phones and / or radios.

Electrical Power

ITS devices require power. Power is required to operate the device, whether it is to raise or lower a gate, or display a message on a variable message sign (VMS). Power is also required to operate the communications equipment. In order for an ITS device to operate it must have power.

The amount of power required depends upon the device. A device such as a traffic monitoring station has low power consumption whereas a variable message sign will have higher power consumption. The amount of power required is directly related to whether a device can operate using batteries and solar power or must be connected to the utility grid.

If used, the appropriate process for designing Photovoltaic (solar) systems can be found via Sandia National labs (NERL) as they provide good resources. Power load is one aspect, but solar resource (insolation) as well as system availability is as important. The VMS design-build contractor for GRSM VMSs overlooked location specific insolation values. Location of solar panels has been a challenge for NPS units as well. Acadia made a change during installation of a solar powered count station to 'hide' a previously agreed to location of a post supporting a solar array away from visitor's view. Unfortunately, this change resulted in placement of the solar array in direct alignment with the shadow of a bed of large trees. In a NPS setting, visual disturbances are to be minimized while ensuring appropriate location of the solar array to maximize exposure to the solar rays.

Devices requiring a low amount of power, or power for only short time periods may be powered by banks of gel cell batteries. (Gel cell batteries are more resistant to freezing than lead acid batteries.) The battery bank is kept in a charged state by a solar cell array. Use of a battery bank and solar cells will require a site evaluation. The number and size of batteries required to power the device must be ascertained. In addition, the number, and size of the solar cells, as well as whether the cells will receive an adequate amount of sunlight to maintain the charge on the batteries must be determined. Solar powered devices in GRSM have not been wholly reliable due to cloud cover and dense forest cover which limit usefulness of solar panels. The new microwave communication system solar power system at Clingmans has been carefully designed to ensure continued operation under GRSM's overcast conditions.

Communications

A situation similar to the provision of electrical power is faced when examining communications. Telephone service is provided to a number of locations along the park boundary, but within the park telephone service is limited or non-existent. Again, different service providers, difficult terrain, and low demand combine to limit the amount of telephone service coverage.

Communications is somewhat different from electrical power in that ITS devices may be connected to either a wireless or a wireline network. Like with power, communication needs are based on the needs of the device. Some devices require more communication capacity than others. For consideration of short-, medium- and long-term communication needs both wireless and wireline networks will be presented in this technical assessment.

A detailed radio or communications coverage assessment will be beneficial input to the design of GRSM's communication plan for the park.

See Project Concept # 8 (Improved Real-Time Information) for information regarding current NCDOT 511 operations and GRSM.

Wireless Connections

A wireless connection to an ITS device makes sense when that device needs to send and/or receive only small amounts of data on an infrequent basis. An example of this type of device would be the previously mentioned roadway gate, or a variable message sign (VMS) which is sent a message to change the displayed information.

Advantages of a wireless connection are easy deployment, lower initial costs, and since most of the required equipment is used at other locations in the park, the Park Maintenance staff has some familiarity with the equipment. Disadvantages of a wireless connection include the expense of operating the system, difficulties in getting good reception in some areas, and disruptions to the connection due to certain weather events.

When wireless communication is considered the type of wireless communication desired and each site must be evaluated to ensure the adequacy of wireless coverage. It is recommended a non-line-of-sight technology be selected over line-of-sight technology for use within the GRSM National Park. Line-of-sight technology, as the name implies, requires a sight line between the sending and receiving antennas. This may be problematic in an environment such as the park as cellular telephone will have poor reception in many locations. However, it is in the best interest of cellular telephone service providers to be able to provide cellular coverage in GRSM.

Wireline Connections

A hardwired or wireline network consists of a physical connection to between one or more central locations and one or more remote locations. The network could be a copper telephone line (commonly called twisted pair), a coax cable, or fiber cable owned by either the public utility or the NPS. To provide access to the interior of the park it is assumed the NPS would need to install and maintain the communication network.

Advantages to a wireline configuration include, lower operating costs, limited possibility of disruption due to weather events and a more consistent connection. Disadvantages include higher cost of initial installation and the environmental disturbance caused by installation.

Wireless Communication Technologies

Technology	Advantages	Disadvantages
Spread Spectrum Radio	• No physical connection required • No FCC license required • Low potential for being interfered with or being interfered by other users • Easy to install (noise immunity) • Moderate reliability (in GRSM)	• Complex to maintain • Line of sight required • Limited video capability
Microwave Radio	• No physical connection required • High bandwidth • Video capability • Moderate reliability (in GRSM)	• Complex to maintain • FCC license required • Line of sight required
Satellite	• No physical connection required • Cost independent of distance – ideal for long distance transmissions • Has video capability • Moderate reliability (in GRSM)	• Complex to maintain • High monthly leasing cost • Large antenna required at each site
Cellular Telephone	• Relatively easy to install • Currently used in GRSM • Moderate reliability (in GRSM)	• Poor reception possible in some locations

Wireline Communication Technologies

Technology	Advantages	Disadvantages
Twisted Pair Cable	• Easy to maintain • Least expensive • Highly reliable • Proven technology	• Limited bandwidth • Minimal video capability • Conduit or overhead wiring required • High cost to install
Coax Cable	• Easy to maintain • High data capacity • Video capability • Highly reliable • Proven technology	• Conduit or overhead wiring required • High cost to install
Fiber Optics	• Very high data capacity • Video capability • Excellent noise immunity • Highly reliable • Proven technology	• Complex to maintain • Conduit or overhead wiring required • High cost to purchase and install

The following section provides some more specific information on Satellite communications and Wi-Fi Standards:

Satellite Communications: Satellite communications are being increasingly used for wireless communications. The table above described some of the advantages and disadvantages of this technology; this section provides some specific details for this technology.

By the end of World War II, the world had had a taste of "global communications." Radio broadcasts from London had electrified American listeners. There was the capability to communicate across the oceans using telephone and telegraph. The first television programs were being broadcast, but the greater amount of information required to transmit television pictures required that they operate at much higher frequencies than radio stations. Take, for example, a radio station that operates at 1020 on the dial. This number stands for 1020 KiloHertz – the frequency at which the station transmitted. Frequency is measured in Hertz.

Today, there are numerous communications satellites in orbit. These satellites provide extensive infrastructure that can be easily used. Satellite system provides a communication media that is capable of transmitting voice and video over any distance without extensive physical communications infrastructure:

Major Components: Major components of satellite communications systems are transmitters, antennae, and power provision. Every communications satellite in its simplest form (whether low earth or geosynchronous) involves the transmission of information from an originating ground station to the satellite (the uplink), followed by a retransmission of the information from the satellite back to the ground (the downlink). The downlink may either be to a select number of ground stations or it may be broadcast to everyone in a large area. Hence the satellite must have a receiver and a receive antenna, a transmitter and a transmit antenna, some method for connecting the uplink to the downlink for retransmission, and prime electrical power to run all of the electronics. The exact nature of these components will differ, depending on the orbit and the system architecture, but every communications satellite must have these basic components.

Transmitters: The amount of power which a satellite transmitter needs to send out depends a great deal on whether it is in low earth orbit or in geosynchronous orbit. This is a result of the fact that the geosynchronous satellite is at an altitude of 22,300 miles, while the low earth satellite is only a few hundred miles. The geosynchronous satellite is nearly 100 times as far away as the low earth satellite. We can show fairly easily that this means the higher satellite would need almost 10,000 times as much power as the low-orbiting one, if everything else were the same. For either geosynchronous or low earth satellites, the power put out by the satellite transmitter is really puny compared to that of a terrestrial radio station. Your favorite radio station probably boasts of having many kilowatts of power. By contrast, a 200 watt transmitter would be very strong for a satellite.

Antennae: One of the biggest differences between a low earth satellite and a geosynchronous satellite is in their antennas. As mentioned earlier, the geosynchronous satellite would require nearly 10,000 times more transmitter power, if all other components were the same. One of the most straightforward ways to make up the difference, however, is through antenna design. Virtually all antennas in use today radiate energy preferentially in some direction. An antenna used by a commercial terrestrial radio station, for example, is trying to reach people to the north, south, east, and west. However, the commercial station will use an antenna that radiates very little power straight up or straight down. Since they have very few listeners in those directions (except maybe for coal miners and passing airplanes) power sent out in those directions would be totally wasted.

The communications satellite carries this principle even further. All of its listeners are located in an even smaller area, and a properly designed antenna will concentrate most of the transmitter power within that area, wasting none in directions where there are no listeners. The easiest way to do this is simply to make the antenna larger. Doubling the diameter of a reflector antenna (a big "dish") will reduce the area of the beam spot to one fourth of what it would be with a smaller reflector. This is described in terms of the gain of the antenna. Gain simply tells us how much more power will fall on 1 square centimeter (or square meter or square mile) with this antenna than would fall on that same square centimeter (or square meter or square mile) if the transmitter power were spread uniformly (isotropically) over all directions. The larger antenna described above would have four times the gain of the smaller one. This is one of the primary ways that the geosynchronous satellite makes up for the apparently larger transmitter power which it requires.

One other big difference between the geosynchronous antenna and the low earth antenna is the difficulty of meeting the requirement that the satellite antennas always be "pointed" at the earth. For the geosynchronous satellite, of course, it is relatively easy. As seen from the earth station, the satellite never appears to move any significant distance. As seen from the satellite, the earth station never appears to move. The low earth orbiting satellite, on the other hand, as seen from the ground is continuously moving. It zooms across our field of view in 5 or 10 minutes.

Likewise, the earth station, as seen from the satellite is a moving target. As a result, both the earth station and the satellite need some sort of tracking capability which will allow its antennas to follow the target during the time that it is visible. The only alternative is to make that antenna beam so wide that the intended receiver (or transmitter) is always within it. Of course, making the beam spot larger decreases the antenna gain as the available power is spread over a larger area, which in turn increases the amount of power which the transmitter must provide.

Power Requirements: One might wonder why transmitters with thousands of watts of power are not used. There simply is not that much power available in some specific areas. There is no line from the power company to the satellite in many cases. The satellite must generate all of its own power. For a communications satellite, that power usually is generated by large solar panels covered with solar cells – just like the ones in your solar-powered calculator. These convert sunlight into electricity. Since there is a practical limit to the how big a solar panel can be, there is also a practical limit to the amount of power which can generated. In addition, unfortunately, transmitters are not very good at converting input power to radiated power so that 1000 watts of power into the transmitter will probably result in only 100 or 150 watts of power being radiated. Transmitters are only 10 or 15% efficient. In practice the solar cells on the most "powerful" satellites generate only a few thousand watts of electrical power.

Satellites must also be prepared for those periods when the sun is not visible, usually because the earth is passing between the satellite and the sun. This requires that the satellite have batteries on board which can supply the required power for the necessary time and then recharge by the time of the next period of eclipse. This was a specific barrier realized in deployment of solar power based VMS signs in GRSM region.

Wi-Fi: 802.11a, WLAN/WiFi denotes a set of Wireless LAN standards developed by working group 11 of IEEE 802. The 802.11 family currently includes three separate protocols that focus on encoding; other standards in the family are service enhancement and extensions, or corrections to previous specifications. 802.11b was the first widely accepted wireless networking standard, followed, paradoxically by 802.11a and 802.11g. The 802.11a standard uses the 5 GHz band, and operates at a raw speed of 54 Mbps. 802.11a has not yet seen wide adoption because of the high adoption rate of 802.11b, and concerns about range. In June 2003, the third standard, 802.11g was ratified. This flavor works in the 2.4 GHz band, but operates at 54 Mbps raw. It is fully backwards compatible with b.

Environmental Considerations

Power and communication lines may be run overhead or underground. Running lines overhead is not recommended due to the long term environmental impact of keeping the lines clear of undergrowth and overhanging branches as well as the potential for breaks in the lines due to branches and / or trees falling across the lines. A better option is to place the lines underground. Because of the sensitive environmental nature of the park, it is recommended the routing of the underground power and communication lines be along a previously disturbed area such as Newfound Gap Road.

At locations where power is currently available, but communications are not, it may be more advantageous to use wireless communication, if possible, to eliminate the negative environmental impacts of placing conduit for communications. The cost in environmental disturbance as well as the installation cost must be weighed against any benefit derived.

Additional environmental considerations include visual impact of overhead wires plus any necessary clearing to provide power or communications. Minimizing visual disturbances is desired.

ITS Communication and Power Needs of Proposed ITS Project Concepts

The ITS Project Concepts presented herein will require a range of different types of power sources and communications medium. A number of concepts can be implemented using power from either the utility grid or an off-grid method such as a bank of batteries. Similarly, the communications required for a number of projects could be provided using either wireline or wireless technology.

Recommendations – determined on a case-by-case basis. In general, consider providing power through battery banks and solar power and communications through the use of cell phones and / or radios for short-term, interim needs. Also consider on a case-by-case basis to provide infrastructure (conduit) during major road repair/rehabilitation projects. This may ease implementation of future ITS deployments (especially power and communication). GRSM to consider upgrading their phone system to better accommodate 511 calls and to better accommodate other communication needs.

Project Concept 6

Improved Road, Weather and Air Quality Information Systems

Considering GRSM park mountainous location, accurate and updated weather and road condition information is absolutely critical for visitors and park officials. GRSM routinely collects information from weather stations inside the park and the National Weather Service (NWS) and disseminates this information. This weather information is shared via radio with park rangers, visitor centers, campground sites and other areas of high visitor concentrations. GRSM also issues a daily weather report to park rangers and at key visitor locations, and is also available on the park intranet site. The park intranet site also provides a link to the NWS Forecast Office – Morristown Tennessee website. Weather and road condition information is also available via GRSM's general telephone number, website, and now users of North Carolina's 511 system will be provided the GRSM general telephone number to access travel information as well.

There are five official locations in the park (LeConte, Newfound Gap, Oconaluftee, Sugarlands and Cades Cove) where weather information (temperature and rainfall) is collected. None of these are automated and each requires a ranger to stop at the location to collect the information.

This Project Concept includes the improving/updating existing weather information collection sites within the GRSM and addition of new sites, as necessary. The updated systems are proposed to include communications of data to the park and integration with other related data in a central information database/clearinghouse for GRSM (Project Concept # 3).

Technology Description: Road and Weather Information systems employ a variety of different types of technology to measure and detect a variety of different weather indicators. Such systems consist of a network of monitoring stations located along primary roads and identified trouble spots, for example bridges or mountainous regions.

The data required for such systems is collected by road and atmospheric sensors. **Road condition sensors** are in-pavement sensors that collect microclimate information and can work with de-icing systems in targeted trouble spots. Measures of road conditions include road surface temperature, condition (wet, dry, etc.), and amount of de-icing materials present.

Surface Sensors – Generally, pavement sensors are embedded into pavement so the top is flush with the surface. These devices can measure numerous conditions on the road surface. These conditions include road temperature, road moisture, what the form of that moisture is (snow/ice/water), the amount of de-icing chemical present on the roadway, and the freezing point of the chemical/water mix.

Subsurface Sensors – Subsurface sensors are generally installed 17 inches below a surface sensor. The small probes indicate when frost appears or disappears from the sub grade. This information is used in understanding the energy balance and for forecasting changing surface pavement temperatures.

Ground Penetrating Radar – Ground penetrating radar is being used for pavement thickness and condition evaluations and for mapping subsurface moisture content. This technology has been deployed using sensors attached to moving vehicles but has not been developed yet for continuous data collection applications.

Atmospheric sensors measure weather conditions at locations adjacent to the roadway. There are several different types of road and atmospheric sensors that measure different elements of roadway and climatic conditions. Atmospheric sensors detect air temperature and humidity, may detect onset and termination of precipitation, wind speed and direction measurement, some also detect visibility reading.

Atmospheric sensors are classified by the type of collected information such as air temperature, humidity, wind speed and direction, precipitation, and visibility.

Recommendations – For the short-term, GRSM to consider updating its existing air quality and weather sensors with ones that allow for remote communications to gather data collected. Consider performing a cost-benefit analysis to determine if adding additional stations is desirable.

Project Concept 7

Enhanced Non-Auto Access to Park Facilities: Transit AVL

One of the best ways of reducing congestion and preserving the park is to offer alternative means (besides personal autos) to access and/or travel around the park. This strategy also reduces the number of vehicle trips into and around the park. This can be accomplished through encouraging the use of public transportation / trolley use and by promoting cycling, walking and hiking. One benefit of enhancing non-auto access is reduced parking issues. A secondary benefit is a more interactive visitor experience. Several communities in GRSM region offer transit service which can be further extended to the park activity centers to provide enhanced non-auto access.

The use of AVL systems for any future transit vehicles that enter the park would be considered an enhancement to the quality of service provided to visitors and to further encourage transit use. Such AVL systems are envisioned to be compatible with and building upon the lessons learned by gateway communities (such as Gatlinburg Transit) with existing or proposed AVL and "Next Bus" type technologies. Use of AVL systems on transit vehicles has the potential both to improve the efficiency of transit operations and to support traveler information systems in GRSM and gateway communities.

Technology Description: AVL technologies have been used successfully by several transit agencies across United States and have provided encouraging benefits. AVL systems also support several other transit ITS applications such as "Next-Bus", traveler information for transit customers, transit signal priority, etc.

A side-by-side comparison of available technologies for transit AVL systems:

Technology	Description	Advantages	Disadvantages
Signpost/ Odometer Systems	The signpost/odometer system has been the most common until recently. In this system, a receiver is mounted on the bus, while transmitters are placed along the bus' route. Utility poles and signposts are most commonly used as mounting locations for these transmitters. The bus picks up a low-powered signal from these transmitters as it passes by, and the mileage noted. When the bus reports its location, the distance from the last pole is used to locate the vehicle's position on a route.	• Low in-vehicle cost; • No blind spots or interference; • Repeatable accuracy. • Proven status	• Requires well equipped infrastructure (Network of signposts); • Maintenance Intensive; • No coverage outside signpost network; • Frequency of updates dependent on density of signposts. • Moderate reliability
Dead-reckoning systems	Dead reckoning is among the oldest navigation technologies. Dead reckoning sensors can measure distance and direction from a fixed point (under the most basic setup, an odometer and compass could be used to calculate position from a specific stop on a route). Typically, these systems act as a backup to another AVL system. This relatively inexpensive system is self-contained on the bus.	• Relatively inexpensive; • Self contained on vehicle (no infrastructure cost); • Only odometer needed. • Proven status	• Accuracy degrades with distance traveled; • Requires direction indicator and map matching systems to track vehicles off-route; • Uneven surfaces and hills can compromise position determination. • Moderate reliability
Radio Navigation/ Location System	Radio-location systems use a low-frequency signal to cover the system, and the buses are located as they receive the signal. Loran-C (Long Range Aid to Navigation) is the most common type of land based radio location	• Low capital cost; • Low maintenance cost. • Proven status	• Monthly service fees can get high with higher use; • Signal attenuation by foliage, tunnels, bridges, and overhead wiring structures. • Moderate reliability

Global Positioning Systems (GPS)	Due to the shortcomings of the other AVL technologies, GPS became the most popular system for new installations over the last few years. GPS utilizes the signals emitted from a network of 24 satellites, which are picked up by a receiver placed onboard the bus. The satellite system covers almost all of North America, eliminating the need to place transmitters/receivers along any route. The existence of the satellite system means that the main cost for the agencies result from purchase of the GPS receivers and equipment to transmit to dispatch. While the U.S. military, which oversees the satellite system, has limited the accuracy of the system in the past, it is now allowing more accurate readings.	• Moderate cost per vehicle; • Global coverage. • High reliability • Proven status	• Subject to multipath errors.

Recommendations – Deployment of this technology among the transit providers surrounding GRSM will be determined by each transit provider. GRSM does not play a role at the onset of these deployments. As GRSM builds its central database, information received from the transit AVL systems may be useful to GRSM staff.

Project Concept 8

Improved Real-Time Information

The need for reliable up-to-date information on road conditions within and around the GRSM National Park is important to both users and employees of the Park. Having this information available in a manner which is readily accessible is key to its usefulness. Whether the information concerns a road closing or delays on park roadways, having this information will allow park visitors to better enjoy their visit to GRSM.

Dissemination of road condition information to GRSM visitors can occur in a number of different ways such as from park employees, through dynamic message signs (recently installed at the Sugarlands and Oconalufee Visitor Centers), hotel and hospitality staff, or media broadcasts. The GRSM has a phone number which can be accessed for weather and roadway conditions, however, as of February 10, 2006, the roadway information could not be found by following the voice prompts. A NPS GRSM website (http://www.nps.gov/grsm/gsmsite/roadinfo.html) containing roadway information is also available.

Technology Description: As described under other Project Concepts, the collection and distribution of roadway information may take several forms. Highway Advisory Radio, Dynamic Message Signs (DMS), traveler 511 systems, internet websites, connections to media outlets, and the provision of information kiosks at various locations all provide a means of disseminating roadway information.

Highway Advisory Road and DMS are discussed under Project Concepts 9 and 11 respectively.

The North Carolina Department of Transportation (NCDOT) has an existing 511 system in place. The current NCDOT 511 system includes a reference to the GRSM general information phone number (1-865-436-1200). The system also includes US Route 441 in North Carolina. NCDOT includes a GRSM transfer option in their 511 system. When a caller selects this option, calls are transferred to the GRSM call center/phone system. GRSM and NCDOT have an existing, signed agreement in place to address this process.

There are some challenges for the NCDOT 511 callers seeking information about GRSM in that many callers may not get the information they are seeking. There is a time-out on the system that does not allow the caller to make a selection before they are transferred back to the main menu. An example of this is if a caller calls for road information and listens to all the options available before selecting the menu option for road information, the time-out mechanism will have been transferred back to the main menu. When the caller presses option 2 seeking road condition information, the caller will be routed to campground information which is #2 on the main menu.

Another system issue is that there is only space for eight callers on the system at any one time and during high demand callers may not get through.

In addition, there is one main means of responding to communications requests in GRSM – including emergencies and calls from park visitors. That means that during emergency situations, the emergency takes priority.

There are several internet websites that discuss roadways within the park, but a recent search of the internet identified only the National Park Service website as having roadway closing information. Hyperlinks to the NPS website could be provided for use on websites containing information on the GRSM.

Sharing information with media outlets can be done by setting up agreements with the media outlet and assigning park personnel the responsibility of getting the information out in a timely fashion. Once a centralized database of information, as describe in Project Concept 3, has been established the dissemination of information should fall to those individuals maintaining the database.

The installation of kiosks at park visitor centers, hotels, and other tourist destinations would also provide a means of getting roadway information out to the public. Kiosks could be hardwired to phone lines or setup in a wireless configuration. Roadway information would be sent to the kiosks by park personnel as changes in roadway status occur.

A number of other proven methods of providing roadway information to en-route travelers exists, such as: DMSs located at transit stops with information regarding the timing of the next bus; internet websites containing maps with color coding indicating speeds; and "push" ATIS systems that send event and incident information to individuals based on their pre-selected routes, times of day, and delivery means. Most of these ATIS options require significant information collection and processing infrastructures is in place before they can be deployed. However, these, and other, methodologies are to be considered during design of ATIS information deployment to ensure the network is designed and implemented in a manner that allows expansion of the initially deployed network to potentially include these and other methodologies.

A brief summary of traveler information techniques is shown below:

Type	**Visual**	**Audio**
Roadway-based	• Dynamic Message Signs	• Highway Advisory Radio
Non-roadway based	• Kiosks • Broadcast display of CCTV • Traveler information websites • Personal digital assistants	• 511 • Radio
In-Vehicle based	• In-vehicle navigation systems (GPS)	• In-vehicle mayday-type systems • Digital radio • Radio

Recommendations – GRSM to continue working with NCDOT and TDOT 511 systems. When Project Concepts 3 and 4 have been deployed to some extent, consider recording/automating information to be shared with the general public. Continue to provide phone access. It is not recommended at this time to deploy other means of information dissemination devices. GRSM to consider upgrading their telephone system to better accommodate future 511 telephone calls and to prioritize incoming calls (between emergency and non-emergency).

Project Concept 9

Upgrade/Replace AM Radio Frequency 1610 Stations

A HAR system is a low-powered AM or FM radio station that broadcasts messages to motorists who receive them through standard automobile radios. GRSM park region has used HAR system (AM 1610) with limited success in the past. There were 12 stations operational in 1980s; however, due to maintenance and aging issues only 3 stations are currently in operation. HAR is effective way of communicating traveler information to drivers and visitors in the park.

Technology Description: A HAR system is a low-powered AM or FM radio station that broadcasts messages to motorists who receive them through standard automobile radios. HAR provides motorist information similarly to VMS but can provide more detailed information. The information broadcast can include:

- Congestion reports,
- Hazardous conditions,
- Travel times,
- Alternate routes,
- Special event information,
- Parking locations,
- Weather and road conditions, and
- Construction information.

Federal Communication Commission (FCC) licensing is required, and each HAR site is limited to a maximum of 10-watts of power. HAR can broadcast either AM or FM radio signals, and the typical message length is up to two minutes.

HAR installation is made up of five separate components:

- Audio Source
- Radio Transmitter
- Antenna System
- Ground System
- Communication System

While there are several different systems within the Highway Advisory Radio category, the type most typically used is the 10-watt "Traditional" HAR. For this application, HAR consists of individual transmitter sites (or stations) located along a roadway, with each transmitter broadcasting at a range of 3 to 5 miles. Communications with each transmitter are typically via dial-up telephone.

Traditional HAR deployments may be either permanent or portable. Permanent HAR sites are often pole-mounted, with the antenna also attached to the pole. Portable HAR transmitters are typically trailer-mounted, with the antenna and grounding plane adapted for a portable application. Portable HAR is typically used for highway construction, incident management and special events. Consisting of a solar power array and cell-phone control, portable HAR are capable of being transferred from site to site, and has a broadcast range near that of permanently built stations (3-5 miles). Portable HAR is licensed by governmental entities for noncommercial broadcasts that relate to travel, safety and weather.

Other HAR include "Low-Power" HAR and system-wide HAR. Although HAR is limited to a maximum power output of 10 watts, "low-power" HAR technology uses a series of interconnected and synchronized 0.1-watt transmitters. This transmission technology may be broadcast over any unused commercial frequency. The main advantage to low power HAR is that the messages transmitted are targeted to specific zones.

Synchronized HAR has increasingly become a popular deployment type, using traditional 10-watt transmitters (3-5 mile radius) systematically placed to create a regional "synchronization zone". Motorists hear the same message anywhere within the synchronized zone. Properly deployed, this type of deployment eliminates interference and delivers a universal broadcast to a synchronized area.

Initial Data Collection for HAR: Prior to determining the type and location of a system detector station, various data needs to be collected, such as:

- Current FCC Licensing Requirements – The designer must obtain the latest copy of the Federal Communications Commission (FCC) rules (section 90.242)
- Frequency availability – Existing HAR frequencies (airports, convention and visitors bureaus, stadiums, etc.) must be documented, in addition to all other radio frequencies. This list will be used upon determining usable frequencies.
- Availability of alternate routes – An inventory of alternate routes and diversion points is necessary to assist in proper placement of a HAR transmitter.
- Speed limits on HAR routes – The speed limit of a candidate route for HAR will determine the spacing required between the HAR flasher and HAR transmitter
- Site Specific Conditions – Soil properties, terrain, and obstructions for the site in question must be gathered. Uses for this information are explained in further detail in the following sections.

HAR Antenna Location: The primary factor contributing to the quality of an antenna location is the effect that re-radiating structures has on coverage. The best antenna site will be located farthest away from a potentially re-radiating source. Re-radiating structures reflect radio energy, which distorts the coverage pattern otherwise expected. Too-close proximity to re-radiating structures results in dead spots, or unexpected areas of non-coverage. Potentially re-radiating structures consist of steel frames, copper wiring, iron, or copper plumbing and would have minimum sizes of:

- Greater than 1/8 the wave length in height (71 meters / 233 feet at 530 kHz; 23 meters / 75.5 feet at 1610 kHz)
- Greater than 1/4 the wave length in length (142 meters / 466 feet at 530 kHz; 47 meters / 154 feet at 1610 kHz)

In addition to influencing the ground plane, tall buildings, water towers, radio towers, and smokestacks are examples of vertical structures that can cause interference. Horizontally, power lines, bridge superstructures, guardrails, and metallic fences can vary field strengths, limiting the effectiveness of HAR. If site selection alternatives are inadequate and such sources of interference are unavoidable, field strength tests should be performed at the site under a temporary HAR operating license to assess the quality of HAR transmissions before committing resources to design and permanent installation.

Adjacent Frequency Considerations: When establishing a 10-watt HAR, license applicants must follow several limitations concerning interference with adjacent radio frequency issues. Interference is primarily signal disturbance caused by other transmitters on an adjacent radio frequency. One signal, being broadcast on too close a frequency to another signal, will take on the characteristics of the second signal. However, there are two scenarios whereby HARs cannot create interference:

- HAR broadcasts cannot interfere with adjacent AM broadcast stations, and
- New HAR sites cannot interfere with existing HAR sites.

AM HAR stations can broadcast at any frequency within the 530-1710 kHz band. To decrease the likelihood of interference, a number of restrictions are included in the FCC rules. The most significant restriction is that the HAR signal source must be located at least 15 km outside the measured 0.5 mV/m daytime contour of any AM broadcast station operating on a first adjacent channel. (540 kHz for a 530 kHz station, 1600 or 1620 kHz for a 1610 kHz station.) These contours are field measured and typically are completed by HAR vendors.

A second restriction is that the HAR must be located far enough away from any AM station operating either on the second or third adjacent channel to avoid interference in AM receivers tuned to the AM broadcast station frequency. Some guidance can be obtained from the FCC for separation requirements as given in section 73.37 (a) of the FCC rules. The following criteria are set forth as the basis for separation between a new and an existing AM station:

For stations separated by 20 kHz:

- The 2 mV/m contours of a new station may not overlap the 25 mV/m contours of an existing station.
- The 25 mV/m contour of a new station may not overlap the 2 mV/m contours of an existing station.

For stations separated by 30 kHz:

- The 25 mV/m contour of a new station may not overlap the 25 mV/m contours of an existing station.

Due to the low power of HAR stations, the 25 mV/m contour will be relatively small and close to the antenna site. The above criteria will generally be met if the antenna site is located outside the 2 mV/m contour of a conflicting second adjacent channel and outside the 25 mV/m contour of a conflicting third adjacent channel. If there are no second or third adjacent channels within approximately 160 km (257 miles), no further proof of non-interference is required.

HAR Equipment Details

<u>Transmitter Housing and Protection</u>

Using a standard Model 332/334 cabinet for HAR transmitter enclosure best addresses environmental concerns. Preferably, a transmitter is located as close as possible to its antenna. With the Model 332/334 cabinet, the transmitter is secured directly to the antenna structure, providing the site with a more electrically reliable system. If situations dictate otherwise, any NEMA Type 3 enclosure may be used to provide a weatherproof enclosure of the transmitter.

The FCC mandates that no unauthorized person may have access to a radio transmitter. Vandalism is also a HAR security concern. The cabinet locks on 332/334 cabinets are likely adequate to satisfy both security concerns, but the cabinet handles also accommodate the addition of a padlock to provide additional security, if deemed necessary.

Antenna System

As discussed above, it is possible that a HAR site might use either a monopole or a cable antenna. Design and installation requirements are detailed as follows:

- Antennas should not exceed 15.0 meters (49.2 feet) in height from ground level.
- Only vertical polarization of the antennas is permitted.
- Transmitter Radio Frequency (RF) output should not exceed 10 watts.
- At a distance of 1.5 km (0.93 miles), emission field strength should not exceed 2 mV/m.
- The antenna should be mounted to the side of the field enclosure.
- If the support structure is metallic, the antenna should be electrically insulated from the structure.
- The antenna should be able to withstand winds of up to 80 mph, and should be all-weather resistant, including icing.
- The antenna should have a grounding system as described below.

Grounding Plane System

Testing should be performed to ensure that there is proper soil conductivity to afford the proper grounding plane for the antenna. A typical ground plane system may consist of twenty radials of No. 10 or 12 AWG copper wires, each approximately 30 meters (98 feet) in length. A 3/4 - inch by 4-foot copper grounding electrode should be connected to each end of the radial and driven into the ground. The entire ground plane system is typically buried 6 to 12 inches below ground level, which serves to minimizing damage and vandalism. Regardless of the exact number, length, and size, ground plane radials are mostly installed in a symmetrical pattern. The radials are then connected at the antenna base where leads are grounded inside the enclosure. Because of the indeterminate nature of soil conditions, additional lengths or radials can be installed to improve signal transmission.

If soil conditions or space constraints do not allow a radial ground system to be installed, copper pipes (usually three areas, 3-5 feet apart) filled with a highly conductive material can be placed around the antenna 10 to 20 feet down into the earth within a minimum 10 foot diameter. The soil type determines the depth of the pipes. Typically weep holes are drilled into the pipes for positive contact to the surrounding earth.

HAR Advance Signing

Signs indicating both the presence of and the frequency at which traveler information is being broadcast should be installed at the beginning of each HAR broadcast area to alert motorists of its presence. Flashing beacons should be installed at each sign, actuated to flash when a special traffic message (other than default) is being broadcast. While other types of technology can be used in placed of beacons, such as blank out or other dynamic message signs, flashing beacons are reasonable for motorist expectation, cost-efficient, and easy to maintain. In designing advance signing for traveler advisory radio, a signing inventory must be performed along the corridor. A minimum of 800-ft spacing must be maintained between the HAR advance sign and other standard interstate signs within the corridor.

These advance notification signs should be placed at the outer edges of the transmission zone, and should conform to the appropriate interstate guide sign guidelines as described in the Manual on Uniform Traffic Control Devices (MUTCD), part II-F. While there are not specific guidelines to the placement of these signs, it is recommended that signs be placed at the fringe of, but within the broadcast zone. Such a location would allow for reasonable perception/response/ reaction time for the motorist to tune to the frequency and listen to the entire message.

If necessary, another notification sign could be placed in the middle of the broadcast zone. To broaden the coverage area, HAR signing could be installed on city streets in advance of the interstate. This might involve modifying the sign design to better-fit local street right of way restrictions.

Flashing beacons should be activated for all non-recurring congestion that may affect traffic along the corridor of travel. Activation of these beacons can be accomplished by radio, mainline communications cable, or leased telephone. Consequently, sighting these advance signs must take into account the availability of AC power and appropriate communications.

Underground Infrastructure

When the transmitter cabinet, pole, ground plane, and advanced signing assemblies have been placed, the underground conduit infrastructure can be designed. Issues to keep in mind when designing the HAR conduit infrastructure include:

- **Conduit Size**. 4-Inch conduit is typically used as cost savings between 4-inch and smaller diameter conduits is minimal and 4-inch conduit may provide for greater future expansion depending on the number of cables and percent fill of the conduit.
- **Conduit Fill**. The size and number of conduits along a run is dependent on percentage of fill as established by the National Electric Code (NEC).
- **Pull Box Spacing**. Pull boxes should be spaced no greater than 200 feet within a HAR. If a conduit run contains only one or two lightweight cables, this distance can be stretched to approximately 300 feet.
- **Terrain**. Conduit infrastructure should be designed on relatively flat (4:1 slope or flatter) terrain. For steeper sloped terrain (4:1 or greater), conduit may be run perpendicular to (i.e., up or down) the slope to locations where the terrain is more suitable for conduit installation.

<u>Controller Equipment</u>

Permanent site, traditional 10-watt HAR controller equipment consist of the following:

- **HAR Transmitter** – 1-10 watts maximum power, 530-1710 frequency range, rack or shelf-mounted.
- **Power Management Interface Unit -** provides switching, fusing and metering for AC and DC power, 24V power supply, 10A float battery charger. Automatic low-voltage battery isolation, auto-reset on restoration of 120V AC.

<u>Power and Communication Requirements</u>

See Project Concept #5.

Recommendations – 10-watt Synchronized HAR to be considered when GRSM replaces/updates existing system. Still to be determined are meeting the communications needs for effective HAR. Nearly 50-foot antenna is not desirable for NPS facilities. A HAR plan (including message content, frequency of messages, exposure time for travelers to the messages, location desirability/effectiveness of messages to be transmitted, complementary means of directing HAR users that a message is available, etc.) is recommended to be completed prior to GRSM consideration of HAR deployment.

Project Concept 10

Automatic Collection of Weather and Air Quality Information

This Project Concept is similar to Project Concept 6, the difference is that it aims at the automation of collection of weather and air quality information within GRSM. At the present time there are five official weather collection locations in the park where weather information (temperature and rainfall) is collected. None of these are automated and each requires a Ranger to stop at the location and read the information.

There are currently eight air quality data collection sites within GRSM. Of these, six have regular telephone or cell phone connections, two use solar power and two include digital cameras. Park staff dials-up these data collection sites to download information.

Automating collection of the weather and air quality information ensures consistent data collection and transmission efforts for GRSM, significantly reducing labor efforts on Park staff. Automatic collection means that GRSM staff do not have to go to each device nor will they have to contact (dial-up) each site – the deployed weather and air quality devices "push" the data collected to the GRSM central database.

Technology Description: Road and Weather Information systems employ a variety of different types of technology to measure and detect a variety of different weather indicators. Such systems consist of a network of monitoring stations located along primary roads and identified trouble spots, for example bridges or mountainous regions.

The data required for such systems is collected by road and atmospheric sensors. **Road condition sensors** are in-pavement sensors that collect microclimate information and can work with de-icing systems in targeted trouble spots.

Surface Sensors – Generally, pavement sensors are embedded into pavement so the top is flush with the surface. These devices can measure numerous conditions on the road surface. These conditions include road temperature, road moisture, what the form of that moisture is (snow/ice/water), the amount of de-icing chemical present on the roadway, and the freezing point of the chemical/water mix.

Subsurface Sensors – Subsurface sensors are generally installed 17 inches below a surface sensor. The small probes indicate when frost appears or disappears from the sub grade. This information is used in understanding the energy balance and for forecasting changing surface pavement temperatures.

Ground Penetrating Radar – Ground penetrating radar is being used for pavement thickness and condition evaluations and for mapping subsurface moisture content. This technology has been deployed using sensors attached to moving vehicles but has not been developed yet for continuous data collection applications.

Atmospheric sensors measure weather conditions at locations adjacent to the roadway. There are several different types of road and atmospheric sensors that measure different elements of roadway and climatic conditions.

Atmospheric sensors are classified by the type of collected information such as air temperature, humidity, wind speed and direction, precipitation, and visibility.

Recommendations – GRSM to consider this type of technology when updating the air quality and weather stations in the park.

Project Concept 12

Incident/Emergency Management Planning*

Providing Incident and Emergency Management Planning for GRSM is a complex task requiring extensive coordination between park divisions, gateway communities, and regional agencies. This Project Concept includes:

- Review and coordination of incident and emergency policies, procedures, and planning activities for the GRSM, gateway communities, and regional agencies
- Development of regional incident / emergency management plans, including the development of detours and alternate routes for use during major incidents / emergencies, to address deficiencies identified during the review.
- Development of a GRSM Disaster Response and Recovery Plan
- Coordination with other GRSM ITS Project Concepts impacted by incident / emergency management activities.

This project may be far reaching in its impact and involvement of different agencies. The project may require the involvement of individuals from the local, regional, state, and national levels. Since GRSM is in both Tennessee and North Carolina, coordination with both states will be required.

Technology Description: ITS is well suited for incident and emergency management. Accurate, timely information is vital to properly managing roadway incidents and emergencies. The ability to quickly provide the public the necessary information to maximize public safety, minimize delays, and reduce the potential for secondary incidents is key. Several of the Project Concepts identified herein contribute to the provision of that information. In addition, several of the Project Concepts will require coordination with the gateway communities. This will assist in the coordination of incident and emergency management planning.

Recommendations – GRSM to participate in incident management/emergency management committees in gateway communities and with other service providers. Aim is to develop IM/EM plans that span boundaries.

Project Concept 13

Operational Strategy Development*

This Project Concept focuses on the policy level institutional coordination that is essential for planning, deployment, and operations of ITS elements in GRSM region. This effort provides guidelines and details about what kind of information exchange is necessary between GRSM Park and gateway communities/other service providers for efficient deployment of ITS and other advanced transportation applications.

This project initiated the necessary starting point for regional coordination. Continuing these efforts after the project is concluded is necessary to create a detailed strategic operations plan for future advancement. Although, GRSM may not be the lead agency to facilitate this kind of coordination, it is recommended that appropriate GRSM staff work with the regional agencies and state DOTs (North Carolina and Tennessee) to develop a regional ITS deployment plan that will facilitate deployment of several ITS Project Concepts presented in this strategic planning project. Sharing the GRSM-centric architecture developed in this effort with adjoining DOTs is a good start towards the development of effective operational strategy development plans – at the very least it will provide a common language to discuss desires of the various entities participating in the operational plan development. The following are some tools to facilitate the institutional communication and coordination.

Regional ITS Working Group: Regional ITS Working group is a tool successfully used by many regions to share ITS planning, operations, and deployment information. GRSM needs to work with gateway communities to participate in (initiate, if necessary) a regional ITS working group for the region. It is highly likely that there will be/are ITS Working Groups that address all of the GRSM-surrounding region – a Tennessee ITS Working Group and a North Carolina ITS Working Group. The ITS Working Group(s) are recommended to consist of policy and operations level people from the stakeholder agencies in the region. It is not recommended that GRSM be the lead agency for this (these) effort(s); however, stakeholder and institutional information provided in this strategic plan provides good background to form such a group(s). The regional ITS working group(s) will encourage sharing information about planned ITS projects and will facilitate working together to reach regional ITS deployment goals. Efficient information exchange among the regional agencies will ensure effective utilization of regional ITS resources, eliminate duplication of any efforts, ensure interoperability between different ITS systems, and provide a platform for coordination for ITS planning, operations, and management.

Working Group Meetings: GRSM regional ITS working group shall arrange periodic meetings to develop and deploy ITS projects in the region. Many regions nationwide conduct such meetings once every month. Based on preference of participating agencies, a periodic schedule shall be planned for regional ITS working group meetings.

Working with State DOTs: GRSM regional ITS working group shall coordinate with both North Carolina and Tennessee DOTs to ensure support for regional ITS activities. Representatives from DOTs shall be invited for regional ITS working group meetings. Regional working group shall ensure that regional ITS activities are in line with statewide ITS plans and comply with the statewide ITS architecture.

Recommendations – GRSM to participate in / with ITS Work Group(s) established by surrounding communities/service providers.

Project Concept 18

Advanced Parking Management System

Parking management is a vital issue for efficient park traffic operations owing to recirculation traffic in the park due to lack of parking and information regarding parking. Visitors are not deterred from their plans to visit park attractions by full parking lots. They often park on the roadsides near the full lots. The resulting parking overflow impacts park resources and creates driving hazards. Hence, an efficient parking management and parking information dissemination are critical for improved traffic operations within GRSM park region. Technology advances have provided several advanced parking management options to assist in this respect.

Parking management systems may include deployment of detectors (capacity monitoring), some type of central software (payment and reporting system) and dissemination devices or systems (driver information). The following technology description provides detailed description for these components of advanced parking management system.

Technology Description: As mentioned, advanced parking management systems primarily include four technology components; vehicle count and tracking system, revenue management system, reports management system, and signing or driver information system. The following description describes these components.

1. Vehicle count and tracking systems

The standard means of tracking parking occupancy are based on detection of presence or movement of the vehicles at parking spaces or at the entrance or exits of the parking facilities. Detection of vehicles is typically provided via sensors or those devices that sense the presence (or lack of presence) of vehicles (See **Project Concept 4**). They are generally used for the purpose of providing or prohibiting access of vehicles into or out of a parking facility. In this usage they are generally linked to a barrier gate. They are also used in conjunction with a counting device, either locally or at a remote PC, and form the basis for estimating dynamically the number of spaces occupied at any given time.

2. Revenue Management System

This section discusses technologies utilized in revenue management systems and in no way constitutes a recommendation for GRSM to collect revenue (entrance fees or parking fees). It presents a discussion of this type of technologies for the reader to gain an understanding of what an advanced parking management system could be. The revenue management system technologies measure the time for which the system is used by the user and charge the appropriate parking fees for that period. Traditionally, revenue management systems use a cashier at the facility to collect revenue; however, modern technologies have been implemented in order to minimize manual cash handling to increase the ease and the security to protect the revenue to the owner to the greatest extent possible.

Lane Equipment: In the traditional method of revenue management systems, there is a ticket counter at the entrance of the facility and a cash counter at the exit. At the entrance, a ticket is issued with a timestamp on it and the number of cars entering the facility is counted for the parking inventory purposes. At the exit, there is a cash counter where cash is collected manually based on the hours for which the facility is used and also the number of cars exiting the facility is counted for the parking inventory purposes.

This system is very simple and inexpensive to install, use and maintain. However, this system offers minimum security with respect to cash handling for the owner and the ingress and the egress activities are usually time-consuming.

Facility Equipment: This method includes a central revenue management system with a back office component that handles the revenue collection and inventory records. In this system, there are automated machines at the entrance that issue tickets with time stamps on them and automated machines that accept the revenue in terms of cash or credit cards at the exit or somewhere on the parking facility. This system can also handle electronic payment collection using special transponders for regular customers; in such a case, the customer has an account with the system and is charged via the transponder based on the number of hours the facility is used.

The back office component of the system handles the revenue collection via automated machines or electronic payment and also keeps the track of inventory of parking spaces by counting the entry and exit vehicles. This system offers improved security for revenue collection by getting rid of the manual component in cash handling and also provides faster ingress and egress from the system.

Facility equipment system can be tied in to various other central revenue collection systems such as tolling by allowing the same transponder to pay for more than one system. This offers improved customer satisfaction as customers can use electronic payment systems to get in and out of the systems quicker while allowing them to use the same transponder to pay for the parking, and also improves the security for the revenue collection as more people are encouraged to use the electronic payment systems.

Special Equipment: This method is comprised of special equipment located off-site of the parking facility at locations that provide easy access for users to pay the parking fees easily instead of waiting at the exit point of the facility. The automated revenue collection machines are situated in big shopping malls, transit stations or as typically seen on the airports near the airport exit for ground transportation. The automated machines can collect revenue in terms of cash or credit cards. This system offers a simple access for the user to pay the parking fees and avoids the bottlenecks at the exit of the facility providing a quicker exit.

3. Reporting system

The key to all good access and revenue management systems is the reporting system. Reports are the product of the system and are used to provide revenue analysis, analyze facility occupancy rates, determine staffing levels and provide accurate data for accounting purposes.

Revenue Analysis: Revenue analysis is used review the revenue collection based on different periods of the day, month or year and the media used for payment by the customers. This analysis helps to determine strategic improvements to maximize revenue from visitors.

Facility Occupancy Analysis: Facility occupancy analysis provides the occupancy records for a particular facility based on the period of the day, month or year. This kind of analysis helps in determining the demand for the facility and helps planning the demand management strategies for the parking facilities.

Staffing Analysis: Staffing analysis provides the basis to determine the staffing level needs based on the demand for the parking management and the system used. This analysis helps allotting the staffing resources appropriately and increases the efficiency of the system.

Accounting Needs: The reporting system provides accurate data for accounting purposes.

4. Sign system

The signage system is intended to provide parking information for drivers to direct them to the available parking spots avoiding the recirculation traffic. Usually, the signage system consists of a combination of static and dynamic displays that provide the information about available parking space, parking fees, etc.

Signs may be used to control access to parking facilities, generally indicating when a facility is full (or partially full), and fixed message signs that display arrows or directions to guide parking vehicles to areas of the facility where spaces are available.

More elaborate signing with programmable messages (VMSs) may contain the number and location of spaces and/or road condition information, are used at locations remote from the parking facility and commanded manually or automatically by computer from a central control site to “guide” vehicles to locations that have available parking spaces. In parking guidance applications these VMS frequently contain both a fixed legend and an area for variable information.

The display format and technology of parking management system displays is selected based on:

- The type of information to be displayed
- Required visibility relative to approach speed and context
- Cost to operate and maintain

Static signs: Static signs are usually used on approaches to the parking facility to direct people to the parking facility so as to minimize the travel in search of the parking spots. Static signs are fairly inexpensive but provide very little and static kind of information in terms of total spots, directions to the parking facility, parking rates, etc.

Variable Signs: Variable message signs use various different technologies to provide elaborate signing with programmable messages. These signs provide both fixed legend type information and variable real time information about available parking spots and other parking information. Samples of these signs are shown below.

The following listing presents descriptions of some of the common variable message sign technologies.

Light Emitting Diode (LED) – generate their own light when the diode is electrically charged. To achieve the brightness levels required for exterior use, the LEDs lamps are clustered into pixels.

Fiberoptic Shutter – Fiberoptic glass optical fibers direct light from a single halogen lamp to the viewing surface, whereby a lens amplifies the fiberoptic dot. Shutters rotate to either expose or block the fiberoptic dot.

Reflective Disk – Reflect light from some external source. The viewing face is formed by an array of permanently magnetized circular disks or rectangular indicators, which when rotated, form the message pattern. They require power only when the message is being changed.

LED Fiberoptic Enhanced Reflective Disk – These hybrid signs combine two VMS technologies to exhibit qualities of both. The pixels in use depend upon the reflective disk principles of operation with the LED or Fiberoptic dot shown when the disk is in the "on" position.

Liquid Crystal Display (LCD) – This technology relies upon an electrical current to change the orientation of crystals to either block or allow back-lighting to be visible on the viewing surface. Legibility characteristics are excellent; however, this technology is very environmentally-sensitive and limited in the brightness output.

Recommendations – GRSM to consider deployment of vehicle count and tracking systems in appropriate parking facilities. Data collected by these devices to be routed ("pushed") to the GRSM central database. Dissemination of parking information to utilize Project Concepts 3 and 8. In addition, GRSM to consider deployment of parking safety/security features such as CCTV at overnight parking facilities.

Project Concept 21

Improved RWIS capabilities

This Project Concept includes the improving/updating of existing weather information collection sites (only – not updating the air quality sites) within the GRSM and addition of new sites, as necessary. As with a similar Project Concept (# 6), this Project Concept encompasses road condition monitoring sites (measuring surface and sub-surface temperature, moisture, icing, salinity, etc). The updated system is proposed to include communications of data to the park and integration with other related data in a central information database/clearinghouse for GRSM (Project Concept # 3). The difference of this Project Concept over Project Concept 6 is that this concept only addresses the weather elements of all the GRSM environmental sensors. The air quality sensors are not addressed in this Project Concept.

Technology Description: Please refer to Project Concept # 6.

Recommendations – For the short-term, GRSM to consider updating its existing weather sensors with ones that allow for remote communications to gather data collected. Consider performing a cost-benefit analysis to determine if adding additional stations is desirable.

II. GRSM ELECTRICAL AND COMMUNICATIONS REQUIREMENTS

In order to support the various ITS systems that have been identified as technologies to consider deploying over the medium- and longer term, a consistent source of electrical power and means of communication must be provided. As noted in Project Concept # 5 (ITS Communications and Power Needs Assessment), most existing power and communications within the GRSM are provided by a mix of public utilities and NPS owned facilities, with other unique power and communication supplies to various locations within GRSM.

One longer term solution is to connect devices located away from reliable and consistent power and communication supplies to the electric grid and provide a physical communication connection to each device. Providing these connections may require that an electric and communication network be deployed within the park. This network is envisioned to consist of providing power, and possibility communication lines to each device.

A. GRSM Electrical Power Requirements

Longer-term, reliable, and consistent electrical power supplied throughout GRSM depends upon the power requirement for all devices (including communications devices) under consideration. In several device locations within GRSM, it may be possible to provide the necessary power (over the long term) using batteries or solar power rather than direct connection to the utility grid. The ultimate, long-term provision of power is likely to be a continuation of many of the short-term power sources – including the addition of direct access to power (via the utility grid) along key routes through GRSM. One such route is likely to be Newfound Gap Road. During the most current reconstruction work on that road, however, no conduit has been installed due to funding shortages.

1. Power from the Utility Company

Connection to the electric utility grid is the general means to provide a reliable and consistent source of power. While this connection exists in a number of locations along the park boundary, providing connection to the electric grid within the park is more problematic. Different utility company service areas, difficult terrain, and low demand all combine to make serving the interior of the park difficult. In addition, park staff are highly reluctant to provide visual disturbances created by overhead wiring.

The longer the distances the power lines are run the larger the required electrical gamble. To minimize the size of the electrical cables required, it is recommend that power along Newfound Gap Road be provided from both the Sugarlands and Oconaluftee entrances. Provision of power along Newfound Gap Road (or anywhere in the park) is recommended to be provided, if possible, by the utility companies. There are advantages to a utility company providing power through the park as utility companies' boundaries are multi-state or regional in nature. The further the range of the electrical grid, the more customers the power company can serve. If this option of power provision is not possible, the park staff needs to closely consider the cost of electrical service to the devices as both upfront and long-term / monthly costs. Typically a higher voltage than required by the ITS devices would be supplied by the cable. At each device a step down transformer would be placed to reduce the voltage to either 120 or 240VAC.

2. Power from Batteries and Solar Cells

As with short-term projects, devices requiring a low amount of power or power for only short time periods are recommended to be powered by banks of batteries (gel cell, as described in Project Concept # 5), or a combination battery bank and solar cells (after a site evaluation). In certain locations within the GRSM National Park, the availability to provide power to a particular location may be problematic – even if a power backbone is provided. (See Project Concept #5 for additional information regarding the design of solar panels.)

B. GRSM Communications Requirements

As noted in Project Concept #5, provision of communications is somewhat different from electrical power in that ITS devices may be connected to either a wireless or a wireline network. Whether it is practical to connect a device to a wireless network depends upon the type and frequency of data being transmitted. Devices such as closed circuit television (CCTV) cameras require a large amount of bandwidth, making a wireless communication impractical. Other devices, such as a roadway gate which is signaled to open or close, have no problem using a wireless connection for communication. The comparison between wireless and wireline technologies can be found in Project Concept #5.

The type of communication medium used depends upon the application, but typically fiber is currently used in most ITS installations. Fiber provides a large amount of bandwidth, enabling the use of CCTV cameras, as well as generally providing spare capacity for future expansion. Fiber can also be used to provide voice communications from locations along the fiber pathway. This could allow the installation of call boxes at strategic locations along the fiber path, and/or additional communication paths between the Sugarlands and Oconaluftee Visitor Centers and supporting park facilities.

As with electrical power, it is in a communication provider's interest to provide fiber and/or cellular coverage through GRSM National Park because it expands their customer base. GRSM may find it beneficial to consider an option where a communications provider supply fiber through the park in return for GRSM receiving use of the fiber.

C. GRSM Power and Communications Environmental Considerations

Power and communication lines may be run overhead or underground. As detailed in Project Concept #5 shown in the table below, it is recommended to eliminate (or minimize) visual disturbances when considering options to provide power and communications in GRSM.

D. GRSM Power and Communications Recommendations

To provide the greatest flexibility, conduits carrying electrical power and fiber optic cables should be installed along Newfound Gap Road. Electrical power is recommended to be provided from both the Sugarlands and Oconaluftee park entrances, with each side providing power to its respective side of the mountain. Fiber is recommended to be run along Newfound Gap Road from Park Headquarters at the Sugarlands Visitor Center to the Oconaluftee Visitor Center. When options arise from service providers (electricity, fiber and/or cellular), GRSM is encouraged to determine how these service providers can expand their network in exchange for expanding GRSM's power and communications capabilities.

Additional electrical power and communication requirements may be encountered with the continued deployment of ITS devices. The implementation of the recommendations contained herein will provide the NPS with the flexibility necessary to respond to these additional requirements.

PROJECT CONCEPT FOR ITS COMMUNICATION AND POWER NEEDS

Project Concept 5 Recommendations for ITS Communication and Power Needs by Project Concepts		
Project Concept	**Power Requirements**	**Communication Requirements**
1. Enhanced Wide-Area Communication System	Mix of battery/solar and utility power	Mix of wireless and wireline
2. Maint. & Work Zone Related Advance Warning System	Battery / solar / generator	Wireless
3. Improved Real-Time Traffic Information Services (ATIS central database)	NA	NA
4. Improved Traffic Monitoring and Detection	Battery/solar and/or utility power	Wireless and/or wireline
6. Improved Road, Weather and Air Quality Info. Systems	Battery/solar and/or utility power	Wireless and/or wireline
7. Enhanced Non-Auto Access to Park Facilities: Transit AVL	NA	Mix of wireless and wireline
8. Improved Real-Time Information	Battery/solar and/or utility power	Wireless and/or wireline
9. Upgrade/Replace AM Radio Frequency 1610 Stations	Mix of battery/solar and utility power	Mix of wireless and wireline
10. Automatic Collection of Weather & Air Quality Info. within GRSM	Mix of battery/solar and utility power	Mix of wireless and wireline
11. Expand use of DMS within and on approaches to GRSM	Utility Power	Wireless or wireline
12. Incident / Emergency Management Planning	NA	NA
13. Operational Strategy Development	NA	NA
14. Automated Incident / Emergency Management System	Mix of battery/solar and utility power	Mix of wireless and wireline
15. Computer Aided Dispatch for Transit	Utility Power	Mix of wireless and wireline
16. Operations Center Coordination	NA	Wireline
17. Automatic Vehicle Location for Park Vehicles	Utility Power	Mix of wireless and wireline
18. Advanced Parking Management System	Mix of battery/solar and utility power	Mix of wireless and wireline
19. Automated Roadway Treatment System	Mix of battery/solar and utility power	Mix of wireless and wireline
20. Automated Gate (Roadway Closure) System	Battery/solar or utility power	Wireless or wireline
21. Improved RWIS capabilities	Mix of battery/solar and utility power	Mix of wireless and wireline
22. Automatic RWIS	Mix of battery/solar and utility power	Mix of wireless and wireline
23. Cades Cove ITS Implementation Planning / System Design	Mix of battery/solar and utility power	Mix of wireless and wireline
24. Newfound Gap Rd ITS Implementation Planning/System Design	Mix of battery/solar and utility power	Mix of wireless and wireline
25. GRSM Spur Rd ITS Implementation Planning / System Design	Mix of battery/solar and utility power	Mix of wireless and wireline
26. Winter Rd Maintenance ITS Implementation Planning / System Design for Newfound Gap Road	Mix of battery/solar and utility power	Mix of wireless and wireline

Appendix C – Early Start ITS Projects

This appendix provides more detailed project descriptions for each of the eight Early Start projects. An Early Start project is one that can begin almost immediately and be completely deployed and operational within 2 years. Each description, reflecting the Project Concept numbering and not a priority order, contains a description, an operational strategy (with a description of implementation concerns and requirements), proposed locations (if an implementation project), and estimated costs. In addition, for the three GRSM-selected Early Start projects (3.1, 4.1 and 8.1), additional information on needed agreements and a potential procurement approach is provided.

Early Start Project 2.1 – Portable Work Zone System

Project Concept Supported:

Project Concept 2 – Maintenance & Work Zone-Related Advanced Warning System

Project Type: Implementation

Project Description:

The specific Project, "Portable Work Zone System", utilizes temporary signs, temporary barriers, PCMS, and PSD devices as a means to provide adequate warnings of closures, detours and travel speeds in work zones within the park. The system will include the acquisition of a sufficient quantity of each component such that multiple (two) work zone operations can be maintained within the park and that sufficient equipment (including spare devices) is provided in order to support at least two (2) one-mile work zones.

The portability of the system will be assured through use of stand-alone power, adaptable either to solar, battery or generator power, along with the ability to mount the equipment on movable stands or trailers as required.

Detailed Operational Strategy

<u>Information to be Obtained</u>

The main types of information which would be obtained through this project include:

- Traffic flow data through work zone (counts, speeds)
- Work zone lane closure information and schedule
- Portable Changeable Message Sign and Portable Speed Detection device status

Traffic flow data shall be collected through placement of temporary measurement devices, which would most likely consist of microwave or laser detection, mounted on portable stands or trailers behind the pavement or the edge of the work zone. Flow data shall be collected continuously during the operation of the work zone, and accumulated for regular updates at user-selected intervals ranging from 1 minute to 15 minutes.

Work zone information for the purposes of this project will possibly be communicated manually from the work zone operator to GRSM Division of Resource and Visitor Protection and GRSM Division of Facility Management staff for further dissemination through the media and ATIS components implemented under other projects. The frequency of this transmission is dependent on the work zone location.

PCMS and PSD devices will be monitored using local control systems, with logging of failures transmitted to a connected personal computer (e.g., laptop).

<u>How the Information Will Be Processed</u>

Speed information from the PSD indicating current speed of a motorist will be collected for immediate display as well as for archiving of speed information for historical and planning purposes.

Work zone information and condition information will be programmed for display over PCMS by the work zone operator, either through instantaneous message programming or through scheduled displays.

The use of laptop computers for programming and monitoring of PCMS and PSD devices may be possible using either serial connections or through IEEE 802.11g local wireless (WiFi) compatibility of the field devices and laptop computer, using secured access.

How the Information will be Disseminated

Speed information for a particular motorist to be immediately displayed on a variable speed display immediately adjacent to the PSD. The purpose of this speed display is to warn traffic to reduce speed immediately through/at a specific work zone location where a speed advisory/limit has been set to allow safe work zone operations. Bright amber LED displays are recommended.

Current and upcoming work zone information and condition information will be displayed on PCMS, both in advance of and, where needed, within a work zone. Bright amber LED displays are recommended.

Related Actions and Procedures to be Executed or Employed

PSD and PCMS, for the purposes of this project, do not require external power or communications support, although future communications capabilities (e.g. wireless GPRS (General Packet Radio Service) or other wireless data communication standards) are to be considered for the devices in support of future remote monitoring and operation.

Control and monitoring of PSD and PCMS may be through software provided on a laptop computer, and possibly monitored directly through serial connections or through wireless networking (WiFi) as discussed above. One computer per PSD (connecting with the speed warning sign) is required; along with one computer for each set of work zone PCMSs. Assuming planning for two concurrent work zones, two laptop computers will be required.

Project Implementation Phases:

- Design Phase: Procurement documents to be developed for equipment as presented above, along with functional requirements derived from the above.
- Installation Phase: Delivery and testing of devices to central yard location, perform testing of equipment prior to implementation in live work zone.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Work zones and related devices naturally cause disruption to the physical aesthetics within the park.
- Communications challenges – System will be stand-alone/portable installation. Connectivity of work zones to central location will depend on the location of each work zone and communications from that point to GRSM operational facilities.
- Utility challenges – Power will have to rely on solar or fuel-powered generation and/or batteries. Portable work zone systems fortunately are oriented to “self-sufficient” operations. Use of solar power could be considered as a potential option but must consider the level of sun which is available in different locations within the park – and also the aesthetics of such equipment.
- A high degree of agency/community cooperation and collaboration – Not relevant to this project.
- Concurrence on the types of information to be shared – Not relevant to this project.
- Concurrence on the types of strategies to employ – PCMS messaging strategies and standards are recommended such that timely, accurate, and understandable information is provided.
- Location of ITS field equipment – Locations dependent on work zone locations – but some locations may have limitations relative to use of solar power and thus other power options need to be available.

- Deployment costs – see project costs below
- Operations and maintenance costs – Operations and maintenance costs of work zone systems need to be provided for within annual budgets for construction and road work activities as well as for particular projects.

Implementation Requirements:

- Operations and maintenance strategy – Follow applicable FHWA, state DOT and manufacturer requirements for operating and maintaining devices, following guidelines from MUTCD. Recommended that vendor be retained to provide maintenance and upgrades to system components for 1 to 3 year period with 2 one-year options (typical approach).
- Procurement approaches – Procurement for work zone equipment can be done using competitive bidding process. Any existing contracts with adjacent communities or Federal Highway Lands Division can be investigated for potential use, particularly proposed construction projects. Another option may include requiring the roadway/work-zone construction contractor to integrate the work-zone warning systems installation, operations, and maintenance as part of the work-zone operations.
- On-going consensus-building –Coordination between GRSM Division of Resource and Visitor Protection and GRSM Division of Facility Management staff is required, along with TDOT, NCDOT and other agencies with interest and connectivity to roads within the National Park, particularly US and state highways.
- Funding – The primary source for funding this project is expected be the Federal Lands Highway Program, either as a stand-alone procurement or included as line items under specific construction projects.

Adjacent Jurisdiction/Community Involvement:

Operational Coordination is appropriate between GRSM and TDOT, NCDOT and other agencies with interest and connectivity to roads within the National Park, particularly US and state highways.

Proposed Locations

There are no fixed locations for this equipment. They will be set up in work zones as needed. Recommended configuration and layout for PCMS and PSD equipment will include an advance PCMS (1/4 mile before work zone) in each direction, a PSD and variable speed display (showing current travel speed) about 500 feet before the work zone. In addition, up to two additional PCMS are recommended for approach routes as well as for messaging within the work zone.

Estimated Quantities

Based on the typical configuration presented above, equipment for two portable work zone systems will consist of the following:

- Per Work Zone: 2 PSD and variable speed displays with control computer, 4 PCMS, plus 1 laptop for PCMS control plus serial or WiFi compatibility for all components / interfaces.
- For two Work Zones: 4 PSD and variable speed display with control computer, 8 PCMS, 2 laptops/PCMS control software with WiFi or serial connectivity.

Project Cost:

The table below provides a planning level estimate of cost for this proposed project concept, utilizing the USDOT's ITS cost database (http://www.itscosts.its.dot.gov) as a basis.

Early Start Project 2.1 - Portable Work Zone System Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[1]
Detailed Design	Procurement documents to be developed, including functional requirements, for portable work zone equipment.	1	Lump Sum	$10,000	$10,000
Portable Changeable Message Sign	Includes portable 3-line LED matrix sign, stand-alone power supply, trailer, wireless or serial network connection	8	Each	$24,000	$192,000
Portable Speed Monitoring (includes Portable Speed Detection and Portable 2-digit Variable Speed Warning Sign	Trailer mounted two-digit dynamic message sign, radar gun, laptop computer, wireless or serial communications; powered by generator or operates off of solar power; and requires minimal operations and maintenance work. The system determines a vehicle's speed with the radar gun and displays the current speed, in real-time, and also stores the speeds in a computer for further analysis.	4	Each	$14,100	$56,400
Laptop Computer with Software	Includes Intel PC laptop with specialized software to monitor and program PCMS.	2	Each	$4,000	$8,000
Component Funding Request					**$266,400**

[1] All cost from the ITS Unit Cost Database – 7/31/06 unless noted.

Early Start Project 3.1 – ATIS Backbone Data Server

Project Concept Supported:

Project Concept 3 – Improved Real-Time Traffic Information Services (ATIS Central Database)

Project Type: Implementation . Selected project by GRSM.

Project Description:

The ATIS Backbone Data Server will compile currently collected transportation related information in the park into one database with a graphical user interface (GUI). Data will then be processed such that it can be geo-located on a GIS reference map incorporated into the ATIS Server and displayed for operators using a map interface. It is envisioned that the operator can select the appropriate map icons to tag the specific information related to that icon (e.g., construction, weather, closure, incident, or event). The information is envisioned to be entered will depict the event type, including location (road and direction), a short description (e.g., accident, fog, road construction), resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

In order to compile, format, and present the data in useful/user-friendly manner for the park users as well as support the future integrated ATIS services, it is advisable to consider the national ITS standards for interoperable information systems. The project will review the full range of standards available and consider using those that will aid in cost-effective system development and / or inter-system interoperability. The ITS-related national standards are designed to facilitate the efficient exchange of information and, as a result, have developed standard data elements and standard messages. Some of these standards, consistent with the national ITS architecture, are quite beneficial to system implementers in reducing the time and resources required to share information between transportation management systems and the 511 support systems.

Currently collected data includes construction and event information, regional weather information, and historical traffic data (from permanent and portable count stations already used in the park). Data collection is not part of this project. The Server will be based at a central location, and could eventually form the core system for a future traffic management or operations center to be developed by GRSM.

Detailed Operational Strategy

<u>Information to be Obtained</u>

The ATIS Backbone Data Server will be manually populated with input information from a number of existing sources, including the following:

- historical traffic flow data to populate the traffic database
- current weather, parking information, scheduled construction and event information, as well as currently-known incidents. This would be done manually by a dedicated operator.

In addition a GIS map of GRSM coverage area will need to be obtained with the system procurement.

How the Information Will Be Processed/Formatted

The operator will input the above information on a GIS reference map incorporated into the ATIS Server using a map interface, as well as using tabular listings of information and event type, location, value, data of input / update, etc.

Utilizing the national ITS standards related to the ATIS and TMDD data dictionaries is vital to ensure the future integration of the systems with real-time information mediums such as 511, wireless, websites, etc. The use of standards relevant to the ATIS and Traffic Management Data Dictionaries will help define data and information standards for initial as well as future traveler information activities and would be required as part of the early-start project.

How the Information will be Disseminated

Dissemination of this information will be addressed in Project 8.1, which provides an Internet-level server which is capable of providing available GRSM traveler information using the web.

Related Actions and Procedures to be Executed or Employed

GRSM staff are to identify, at the minimum, an interim or initial operations facility in which to place the ATIS Server, including workstation. While the initial system deployed under this project will not yet be automatically processing real-time data, it will accept weather, construction and event information which may be useful in operation of the existing two changeable message signs within the park and in providing information to the media, other agencies, or the traveler information website being developed under Project 8.1.

The operations period for the system, at this time, would be normal working hours, with the exception of emergencies or specific conditions where required information would need to be input to the system. To this end, remote Internet access to the system from authorized personnel in order to input key information (such as construction, forest fires, or immediate road closures) should be provided.

The system is to be procured from a system integrator and thus the configuration may differ depending on the individual integrator's approach to the server operation. *It is recommended that GRSM consider procuring Projects 3.1 (ATIS Backbone Data Server and 8.1 (Early Start Dissemination) as a single procurement, with an aim to assure compatibility and interoperability between data collection, processing, and information dissemination.*

Project Implementation Phases:

- Requirements and Procurement Document Development: A set of detailed functional requirements for initial system deployment and future system expandability shall be developed as the basis for system integrator procurement. This will include testing, training, documentation, warranty, and system software/hardware support requirements. These detailed functional requirements will be developed by the GRSM selected consultant or EFL.
- Installation and Integration: A system integrator is to be retained by GRSM to produce and integrate an ATIS Backbone Data Server system which meets the detailed functional requirements identified in the design phase.
- Operational Support: The system integrator is to be retained by GRSM to provide hardware and software support services to ensure periodic as well as need-based maintenance of the ATIS server.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Not relevant to this project, since it is mainly a centralized communication system.
- Communications challenges – Relevant for field devices under other projects which may be integrated with the ATIS in the future
- Utility challenges – Utility challenges not an issue for this project.
- The ability to balance all the theme areas (visitor experience with preservation with improving operations and safety, etc.) – Ability to provide timely traveler information will help enhance the visitor experience.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – Operations and resources needed for the system (including staffing to monitor and manage the system) must be identified, as with any technology deployment. System maintenance skills and capabilities require both available staff and adequate training in maintaining the various components. In this case, an operations and maintenance agreement with the system integrator is recommended.
- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – Not relevant to this specific project.
- Many deployments require appropriate levels of information sharing among providers – This will not be relevant to this project
- A high degree of agency/community cooperation and collaboration –This is not relevant to this particular project
- Concurrence on the types of information to be shared – Not required for this project. However, use of national ITS standards related to the ATIS and Traffic Management Data Dictionaries is vital to ensure the future integration of the systems with real-time information mediums such as 511, wireless, websites, etc Utilization of the national ITS standards for information formats will ensure easy interfaces with TDOT and NCDOT for statewide/regional ITS information sharing; and the ability of local agencies to provide incident, closure and event information which can be input in a standard format into the ATIS and then made available to users.
- Concurrence on the types of strategies to employ –Not relevant to this project
- Location of ITS field equipment – Not relevant to this project.
- Deployment costs – see project costs below
- Operations and maintenance costs – Operations and maintenance costs vary based on the system configuration, the level of custom software, and the level of sophistication.

The biggest challenge to deploying the ATIS is that the initial system will rely on manual input of incident, construction, weather, closure or special event information as well as historical traffic information. Secondly, in order to assure that the system can be expanded to address future needs, there will need to be a more extensive "upfront" software requirements effort and investment (although this would reduce future project costs).

Implementation Requirements:

- Operations and maintenance strategy – Recommended for system integrator to provide software / hardware maintenance throughout deployment process – meaning they could be "on call" to provide ATIS enhancements as appropriate. Recommended that vendor be retained to provide maintenance and upgrades to system components for 1 to 3 year period with 2 one-year options (typical approach).
- Procurement approaches – see below.

- On-going consensus-building – Coordination between different departments within GRSM staff is critical. This is not as relevant to this project from the perspective of other agencies, since the data collection and monitoring is focused within the park itself.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Proposed Locations

Initial ATIS Backbone Data Server is to be located at the park's central offices in a location to be defined by GRSM staff which is conducive to central operations.

Estimated Quantities

The quantities and equipment depend on the configuration provided by the system integrator to address the system requirements, but at the minimum would likely include the following:

- ATIS Data Server and Operator Workstation (1 computer minimum, including map engine and, for operator workstation, custom user interface which is expandable for future improvements)
- A detailed systems requirement and procurement document
- Independent verification and validation
- System integrator service contract to ensure system set-up and testing to comply with the systems requirement documents and continually support the operations/maintenance of the ATIS server system

Project Cost

The table below provides a planning level estimate of cost for this proposed project concept, utilizing the USDOT's ITS cost database (http://www.itscosts.its.dot.gov) as a basis.

Early Start Project 3.1 - ATIS Backbone Data Server Cost Estimate

Item	**Description**	**Qty**	**Unit**	**Unit Cost**	**Item Cost[2]**
Requirements and Procurement Document Development	Procurement documents to be developed, including functional requirements, for ATIS server	1	Lump Sum	$35,000	$35,000
Hardware for ATIS server	Includes ATIS server plus one operator workstation	1	Lump Sum	$10,000	$10,000
Software for ATIS Server	Includes off-the-shelf software map database and user interface.	1	Lump Sum	$80,000	$80,000
Integration for ATIS Server	Includes all software customization, integration with external interfaces, testing, documentation and training.	1	Lump Sum	$100,000	$100,000
Component Funding Request					**$225,000**

Agreements

After discussions with GRSM staff it was established that no agreements are necessary outside of GRSM to implement the project. That means that the NPS does not need to establish agreements with entities adjacent to or outside of GRSM boundaries. It is likely that GRSM may need to establish agreements within the NPS, internally among GRSM divisions, and with FHWA EFLHD.

Procurement Approaches

For this project, there could be potentially two stages of procurement for a seamless design and deployment of this project. In the first stage, GRSM can either hire an engineering design consultant, use FHWA's EFLHD support, or use the GRSM internal technical/professional resources to develop the system procurement RFP. The resulting RFP will include a set of detailed functional requirements for initial system deployment and future system expandability as the basis for system integrator procurement. The RFP will specify GRSM's needs for testing, training, documentation, warranty, on-going system support and maintenance services, and system software/hardware support requirements.

In the second stage, GRSM will release the RFP developed in the first phase to seek competitive offers to provide system integrator services. GRSM staff, EFLHD, or the engineering consultant hired for the first phase will be involved in the review of the proposals, selection of vendor, and the contract performance oversight. The second stage-selected vendor will produce necessary documentation and deploy/install the system for GRSM. The first phase support will provide independent verification and validation input to GRSM throughout the deployment and initial system operations.

[2] All cost from the ITS Unit Cost Database – 7/31/06 unless noted.

Early Start Project 4.1 – Initial Traffic Monitoring Sites

Project Concept Supported:

Project Concept 4 – Improved Traffic Monitoring and Detection

Project Type: Implementation. Selected project by GRSM.

Project Description:

This project will concentrate on improving existing traffic data monitoring and detection capabilities, through deployment of data collection technologies such as inductive loops (sensors placed in the road) or non-intrusive sensors (sensors placed above the road) at current data collection locations. Data collection technology will be determined on a location by location basis; the process for technology selection is described in the implementation phase section of this project.

The prioritization of implementation sites and the technology to be deployed at each site will be guided by power and communication capabilities at existing traffic data monitoring and detection locations throughout the park and input from park authorities. It may be possible to provide near-real time data collection depending on the current communication capabilities at selected locations.

Traffic flow data shall be collected through placement of non-aesthetically intrusive or non-intrusive detection devices, which would most likely consist of inductive loop detection mounted under the pavement, or non-intrusive detection on short poles, either wood or painted to be as unobtrusive as possible. Poles "disguised" as trees or bushes have been used by the industry and could be considered an option. Small, well disguised equipment cabinets (e.g., NEMA Type B enclosures) would be mounted on pedestals at least 10 feet from the edge of pavement.

Detailed Operational Strategy

<u>Information to be Obtained</u>

The following shall be obtained as a result of this project:

- Quantitative traffic flow data, possibly including real-time traffic volumes, speeds and occupancy/congestion information at the current data collection locations

If appropriate communications capabilities are available, flow data shall be collected continuously and accumulated for regular updates at operator-selected intervals ranging from 1 minute to 15 minutes.

<u>How the Information Will Be Processed</u>

Data from traffic flow detectors will be collected at the user-selected intervals (if appropriate communication channels are present) and used as follows:

- Operator display of traffic flow status on roads through GRSM
- Storage and archiving of 15 minute, hourly, or other selected interval of traffic count, speed or other detector data for transportation planning purposes
- Comparison of flow data/queuing information against parameters to be used for trigging an alarm relative to a potential incident.

<u>How the Information will be Disseminated</u>

Information generated from detector devices will be used for studies in order to identify future traffic and incident management strategies. The data will also be available for dissemination under projects developed under Concepts 3 and 8, using standardized center-to-center or local area network interfaces (e.g., XML) between the components developed under this project and future project components developed in the short term (0 to 5 years).

Related Actions and Procedures to be Executed or Employed

In addition to the activities as discussed above, there are more fundamental considerations. To implement detection equipment, both power as well as communications to the GRSM operations facility will be required at the specific locations discussed below. In light of limitations with solar power, the detailed design will require definition of available power connections where solar panels are not a feasible option. The need for communications infrastructure for the proposed sensor network is to be examined in combination and as part of the project concept 5.1 (which is also an early-start project), which will focus on developing a communications master plan for transportation purposes within the park.

Project Implementation Phases:

- Design Phase – GRSM / EFL to (or hire a consultant to):
  - Recommend which type of technology to be deployed at each location based on power and communications available at each location.
  - Develop requirements and functions needed for monitoring and summarizing the information from the roadside.
  - Prepare and oversee consultant vendor selection documents and process.
- Installation Phase– This phase includes procurement, installation, integration, and testing of the system, including review of contractor submittals, independent verification and validation testing, and final acceptance based on the design documents. The selected contractor will deploy the agreed-to technologies. Either EFL or a consultant hired to assist in the design phase is recommended to perform independent verification and validation (IV&V) on the deployed elements and resulting system.

Implementation Barriers:

- The desire to minimize visual disruption of the park – some traffic detection technologies can affect aesthetics; however, selection of appropriate technology can limit such impact. For example, inductive loop detectors are embedded in the road in general would provide less visual impact than, say, above-ground microwave sensors or CCTV cameras. Cabinets will impact aesthetics, however, every attempt will be made to reduce the visual impact from the cabinets.
- Communications challenges – No applicable to this project as there are no plans to upgrade communications in the early start project.
- Utility challenges – Utility challenges include limited access to electrical or communications facilities within the park. Use of solar power could be considered as a potential option but the level of sun which is available in different locations within the park, and also the aesthetics of such equipment, must be considered.
- The ability to balance all the theme areas (visitor experience with preservation with improving operations and safety, etc.) – Provision of enhanced traffic detection capabilities will help provide improved traveler information to the visitors, thus, enhancing the visitor experience.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – Operations and resources needed to operate the system (including staff to monitor and manage the system) must be identified within

GRSM, other government resources or through consultant support, as with any other technology deployment. System maintenance skills and capabilities require both available staff and adequate training in maintaining the various components. This may be handled through separate maintenance agreements with the equipment vendors or with experienced electrical contractors or maintenance firms.

- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – see "Utility Challenges" above.
- Many deployments require appropriate levels of information sharing among providers – Not applicable to this project – since it focuses on the collection of data within the park itself.
- A high degree of agency/community cooperation and collaboration – Not applicable to this project – since it focuses on the collection of data within the park itself.
- Concurrence on the types of information to be shared – Not applicable to this project; to be addressed as part of other projects which identify what information needs to be shared.
- Concurrence on the types of strategies to employ – Not applicable.
- Location of ITS field equipment – Only existing locations will be assessed, based on available power and communication considerations.
- Deployment costs – see project costs below
- Operations and maintenance costs – Operations and maintenance costs vary based on specific technologies deployed.

Implementation Requirements:

- Operations and maintenance strategy – Recommended that equipment vendor be retained to provide maintenance and upgrades to system components for 1 to 3 year period with 2 one-year options (typical approach), as well as provide training to GRSM roadway maintenance staff on definition of problems and corresponding actions needed.
- Procurement approaches – see below.
- On-going consensus-building – Coordination between different departments within GRSM staff is critical. Not as relevant to this project from the perspective of other agencies, since the data collection and monitoring is focused within the park itself.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Proposed Locations

Park portals currently include loop detection systems for counts in/out of the park, and GRSM maintains fourteen (14) permanent count locations and additional portable counters. Under this early start project, the following permanent stations will be replaced by upgraded traffic detector stations. These locations are as follows:

Portal locations:

- US441 (southern portal near Ocanaluftee)
- US441 (northern portal near Gatlinburg)
- Route 73 (Townsend portal)

Tube counter location replacements:

- Balsam Mountain Spur Road (northbound only);
- Heintooga-Round Bottom (northbound entrance lane);
- Foothills Parkway (west section) from US 129 Northbound Access Lane;
- Bryson City-Fontana Road Entrance;
- Greenbrier Ranger Station Southbound Entrance Lane;
- Cherokee Orchard Road Northbound Lane;
- Foothills Parkway (west section) from Tennessee Look Rock Southbound Access Lane;
- Rich Mountain Road;
- Parson Branch Road;
- Cades Cove Loop Road
- Tremont (Inductive loop counter)

Estimated Quantities

Fourteen (14) detector stations as listed above, of which 7 stations are single-direction and 7 stations are in two directions, will be implemented under this initial project. One control cabinet will be provided per detector station.

Project Cost:

The table below provides a planning level estimate of cost for this proposed project concept.

Early Start Project 4.1 – Initial Traffic Monitoring Sites Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[3]
Detailed Design	Design Plans for upgrading the current detection stations, including assessment of existing locations and feasibility of enhancements. Includes requirements for new equipment, procurement support and installation/upgrade oversight, etc.	1	Lump Sum	TBD	$[4]90,000
Detector Station	Detectors, transceiver, cabinet, electrical service and pole, and communications connectivity	14	Each	$25,000	$350,000
Traffic Count System (central equipment hardware, software and integration)	Central system for monitoring of detector data (off-the-shelf)	1	Lump Sum	$80,000	$80,000
Component Funding Request					**$520,000**

Agreements

After discussions with GRSM staff it was established that no agreements are necessary outside of GRSM to implement this project. That means that the NPS does not need to establish agreements with entities adjacent to or outside of GRSM boundaries. It is likely that GRSM may need to establish agreements within the NPS, internally among GRSM divisions, and with FHWA EFLHD.

Procurement Approach

The procurement for this project will be a two stage process. In the first stage, GRSM will hire an engineering consultant, utilize FHWA EFLHD staff, or use current GRSM staff to study and

[3] All cost from the ITS Unit Cost Database – 7/31/06 unless noted.

[4] Cost based on previous experience. Cost will depend on selection of technology and detail design requirements including location, quantity, and functional requirements

recommend the best technology option to be deployed for the initial traffic monitoring sites that will be replaced. The GRSM support during the first phase will develop the detailed procurement specifications for the GRSM selected technology option. The procurement package will be prepared in the form of an RFP to be released for the competitive bidding process.

In the second stage, the GRSM will release the RFP developed in the first phase to seek competitive offers to deploy/install the replacement traffic monitors. GRSM staff, EFLHD staff, or the engineering consultant hired for the first phase will be involved in the review of the proposals, selection of vendor, and the contract performance oversight. The second stage-selected vendor will produce necessary documentation and deploy/install the system for GRSM. The first phase support will provide independent verification and validation input to GRSM throughout the deployment and initial system operations.

Early Start Project 5.1 – GRSM-Wide Detailed Communications and Power Needs Assessment

Project Concept Supported:

Project Concept 5 – ITS Communications and Power Needs Assessment (planning effort)

Project Type: *Study*

Project Description:

The objective of this project concept is to undertake a comprehensive review of existing facilities, proposed ITS project concepts, and identify appropriate power and communication technologies consistent with this project's themes, including environmental and preservation concerns. This study will undertake the study/development of a comprehensive transportation power and communications master plan for the GRSM Park. To ensure a comprehensive transportation master plan development, it is critical to consider existing as well as future needs (including ITS Deployments) for power and communications within the park.

The power element of the master plan will focus on researching and evaluating different methods of providing power for existing as well as future ITS equipment in the park. The project will develop a plan with recommendations for power source development for different technologies and locations within the park.

The communications element of the master plan will focus on researching and evaluating different methods of providing communications infrastructure within the GRSM Park. The project will develop a plan with recommendations for communications infrastructure development for different technologies and locations within the park.

The transportation power and communications master plan will also cover recommendations for contracting and procurement of recommended power and communications infrastructure.

Detailed Study Strategy

Information to be Obtained – GRSM / EFL (or hire a consultant) to obtain:

- Current electrical power needs, drops/access points within the park.
- Locations within park where the use of solar power (access to natural light) is strictly limited/available
- Existing wireless signal profiles from mobile phone carriers within the park, including tower locations.
- Definition of future bandwidth needs based on optimal detector and CCTV coverage, communication to portable work zone locations (requires signal propagation analysis)
- Current "state-of-the-art" in wireline and wireless communications technologies to support the future needs. This analysis will address capital and construction costs as well as operations and maintenance costs.
- Park, construction, and environmental constraints in implementing wireless and wireline communications options as well as power options

How the Information Will Be Analyzed – the consultant will:

- Assess cost and functional trade-offs between various communications options along with physical limitations within the park
- Assess cost and functional trade-offs between various power options along with physical limitations within the park

How the Information will be Disseminated – the consultant will:

- Recommend power and communications options for the GRSM park will be documented as the power/communications master plan. The plan may contain technology and location specific recommendations for current as well as future ITS deployments.

Project Implementation Phases:

Project will be a study with distinct recommendations that may be incorporated into other projects.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Not relevant to this project
- Communications challenges - Not relevant to this project
- Utility challenges –Not relevant to this project
- The ability to balance all the theme areas (visitor experience with preservation with improving operations and safety, etc.) – Enhanced communications systems and power access will enable implementation of real-time sensors and information devices within the park. Doing the study is the first step.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – Not relevant to this study
- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – Not relevant to this project
- Many deployments require appropriate levels of information sharing among providers – Not applicable to this project.
- A high degree of agency/community cooperation and collaboration – Not relevant to this project
- Concurrence on the types of information to be shared – Data requirements and standards, as well as video standards and bandwidth requirements, will be defined as the basis for communications requirements in the study.
- Concurrence on the types of strategies to employ – Not relevant to this project.
- Location of ITS field equipment – Locations of proposed traffic detection stations (Project 4.1) as well as potential future components will need to be assessed as an integral part of this study.
- Deployment costs – Deployment costs will be developed as part of the alternatives comparison for communications and power.
- Operations and maintenance costs – Operations and maintenance costs vary based on specific technologies deployed.

Implementation Requirements:

- Operations and maintenance strategy – Study will identify options for communications and power equipment procurement, operation and maintenance.
- Procurement approaches – Procurement to be based on technical proposals which best provide the qualifications for the consulting services to perform the power and communications plan study, after which negotiations for price could occur.

- On-going consensus-building – Coordination between different departments within GRSM staff is critical, as well as with other agencies or authorities who have control over electrical and communications links and may be affected by or will participate in the study/study outcome.
- Funding – The primary source for funding this study will be the Federal Lands Highway Program.

Adjacent Jurisdiction/Community Involvement:

Use of, and proposal to use, various power and communications alternatives outside the park boundaries is to be considered by the selected consultant team, including local, private, and regional. Cooperation and coordination agreements to use other agency's communications components, as well as competing power companies, should also be considered as a key part of the alternatives analysis for this study.

Proposed Locations

Locations of power and communications routings, hubs, and radios will be identified in the study based on the overall assessment of device locations, availability of services, and ability to implement wireline and wireless devices in as unobtrusive a fashion as possible. The communication locations will depend on the use of fiber, microwave, mobile phone, and wireless networks (including continuous wi-fi links, wireless mesh networks, etc.), solar, etc.

Estimated Quantities

Study will identify the required power and communications equipment based on the above detailed assessments.

Project Cost:

Expected study cost is $300,000 based on comparable work effort required to complete this study.

Early Start Project 6.1 – Integrate Existing Road Weather & Air Quality Information

Project Concept Supported:

Project Concept 6 – Improved Road Weather and Air Quality Information Systems

Project Type: Implementation

Project Description:

This project focuses on integrating existing road weather and air quality information into the GRSM ATIS backbone data server (Project 3.1).

As the information is currently collected manually, the integration effort addressed in this project will include manual entry of the data collected into the ATIS backbone data server.

Integration of existing weather and air quality stations will enable park operations staff to more easily access this data, rather than sporadically sharing information via radio. More access to this information aims to enhance uniformity and reliability of the conveyed message, ultimately enhancing the park operations and the visitor experience.

Later projects may address upgrading and expanding the road weather and air quality information collection capabilities within GRSM park region. Future projects may be divided into upgrading existing weather and air quality stations, additional integration of information collected, and examining the need for additional stations.

Detailed Operational Strategy

<u>Information to be Obtained</u>

Current weather and air quality information will be obtained and input into the ATIS Backbone Data Server (Project 3.1).

<u>How the Information Will Be Processed</u>

A member of GRSM staff will input the data in text format suitable for presentation to the public into the ATIS Backbone Data Server.

<u>How the Information will be Disseminated</u>

In coordination with other early start projects, a GRSM Travel Information Home Page could include of a map of GRSM with current information events icons shown on it. The map would contain the ability for the user to click on an icon to bring up the specific information (e.g., construction, weather/air quality, closure, incident, or event), which could be shown in a pop-up text box. The pop-up text box would show the event type, including location (road and direction), a short description (e.g., accident, fog, road construction), resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

In addition to the above "main map", it may also be possible to click on text listings of these same event types, and bring up pages which list the particular event type, including location (road and direction), type of event, resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

Related Actions and Procedures to be Executed or Employed

Project 3.1 will display the information on the GRSM Traveler Information Web Page. It is expected that updates to the information displayed will occur as updates are entered into the ATIS backbone.

The weather and air quality data will be input by a GRSM staff position, however, the user interface that the GRSM staff member will enter the information into will be procured from a system integrator. The exact requirements for data entry will differ depending on the selected integrator's system.

Project Implementation Phases:

- Planning Phase
  - Evaluate the potential to upgrade existing weather and air quality stations
  - Evaluate GRSM staff capabilities to operate / maintain the input system
  - Develop a concept of operations and requirements specific to RWIS and air quality – for this project, this will address only the existing information integration effort.
- Design Phase – Under this phase, the recommendations suggested in the planning phase will be further detailed for the development of documents as needed to procure and install the necessary equipment and systems, such as:
  - system requirements and specifications documents
  - field design plans
  - communications schematic and requirements
  - requirements for testing and installation as part of the equipment procurement process
- Installation Phase – this phase includes procurement, installation, integration, and testing of the system, including review of contractor submittals, independent verification and validation testing, and final acceptance based on the design documents.

Implementation Barriers:

- The desire to minimize visual disruption of the park – No additional impact on visual aesthetics of the park.
- Communications challenges –Existing wireline communications are already in place and will be utilized.
- Utility challenges – Existing utility / power will be utilized; no additional challenges.
- The ability to balance all theme areas (visitor experience with preservation with improving operations and safety, etc.) – this project seems to balance the themes effectively by providing more information to enhance informed operations and safety with no impact on visual aesthetics of the park.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – Staff capabilities to operate and maintain this proposed system will need to be assessed to determine impact on current operations, however, the staff requirement once the learning curve has been overcome will be minimal.
- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – Not applicable to this project.
- Many deployments require appropriate levels of information sharing among providers – Not applicable to this project – since it focuses on the collection of data within the park itself.
- A high degree of agency/community cooperation and collaboration – Not applicable to this project – since it focuses on the collection of data within the park itself.

- Concurrence on the types of information to be shared – Not applicable to this project – since it focuses on the collection of data within the park itself.
- Concurrence on the types of strategies to employ – Not applicable to this project – since it focuses on the collection of data within the park itself.
- Location of ITS field equipment – Additional equipment, if necessary, will be located in existing facilities rather than in the field.
- Deployment costs – Please see project costs below
- Operations and maintenance costs – Operations and maintenance costs will be minimal; however, they may vary based on technologies deployed.

Implementation Requirements:

- Operations and maintenance strategy – System integrator for project 3.1 to conduct training for any and all GRSM staff that may need to access or input any weather/air quality data into the ATIS Backbone. Recommended for system integrator vendor to be retained to provide maintenance and upgrades to system components for 1 to 3 year period with 2 on-year options (typical approach).
- Procurement approaches – Procurement for system integrator to be by RFI, RFQ, RFP, or IFB. Combine system integrator procurement with other early start projects. Recommendations development (also recommended to be combined with other early start efforts) to be completed prior to procurement of system integrator services.
- On-going consensus-building – Coordination between different departments within GRSM staff is critical. Not as relevant to this project from the perspective of other agencies, since the data collection and monitoring is focused within the park itself.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Proposed Locations

It is proposed the weather and air quality data input access be configured so that this information may be entered into the ATIS backbone as conveniently as possible. If the information that is collected physically arrives in several locations in GRSM headquarters or on GRSM property, it is expected that the GRSM staff member(s) responsible for receiving that information will also enter it into the ATIS Backbone locally (not have to travel someplace else to enter the input). The desire is for the data entry screens to be located and password protected on a GRSM server so that any computer connected to the server can access the data entry screen. The data entry portion of the system could be remotely supported through something such as Virtual Private Network (VPN) access over the Internet or a dedicated data link.

Estimated Quantities

Proposed project would consist of new software to process and present weather and air quality information input into the GRSM ATIS Backbone and any additional storage/capacity necessary to accommodate and store this component. It also includes any incidental equipment required to network this server or section of an existing server with the ATIS Backbone Data Server developed in Project 3.1 (either at the GRSM operations facility or remotely).

Project Cost:
The table below provides a planning level estimate of cost for this proposed project concept.

Early Start Project 6.1 – Integrate Existing Road Weather & Air Quality Information Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[5]
Requirements Development	Consultant to develop operational, performance, and system requirements for input into procurement documents (may be combined with other early start efforts to gain economies of scale)	1	Lump	$45,000	$45,000
System Design and Training	System Integrator – typically the same as would create Project 3.1 (ATIS Backbone). Line item only reflects additional costs for this component in design and training.	1	Lump	[6]$45,000	$45,000
Central Equipment for RWIS	Central equipment includes CPU, workstation with RWIS ATIS software, and any communications equipment.	1	Lump	$13,000	$13,000
Central Equipment for Air Quality Monitoring	Central equipment includes CPU, workstation with air quality ATIS software and any communications equipment.	1	Lump	$13,000	$13,000
System Testing	Combine with other integration/system efforts	1	Lump	$5,000	$5,000
				Component Funding Request	**$121,000**

[5] All cost from the ITS Unit Cost Database – 7/31/06 unless noted.
[6] Cost based on previous experience; accurate cost will depend on detail design requirements.

Early Start Project 8.1 – Initial Internet-Based Dissemination

Project Concept Supported:

Project Concept 8 - Improved Real-Time Information (dissemination only)

Project Type: Implementation. Selected project by GRSM.

Project Description:

Project 8.1, will provide an Internet-level server which is capable of providing GRSM traveler information to the public using the web. This deployment will focus upon the data which is input into the ATIS Backbone Data Server (3.1) – roadway construction, event, and closure information as well as weather information. The information will be available to the public both as a listing and related geographically to a park map showing roadways and points of interest. This project also will disseminate GRSM's ATIS database (Early Start Project 3.1) to existing web-based traveler information systems in the surrounding communities (such as the NCDOT and TDOT 511 systems) – up to three (3) interfaces. The functional requirements for the web-based dissemination system will be developed by EFL or the GRSM-selected technical consultant.

Detailed Operational Strategy

Information to be Obtained –

Information which is generated from the data input into the ATIS Backbone Data Server (Project 3.1) will serve as input to this project, including:

- GIS map of GRSM coverage area
- Operator-input weather, scheduled construction and event information, as well as currently-known incidents. The interface for this information will permit such data to be automatically updated on the website once the information has been input at the data server.

How the Information Will Be Processed

An Internet server will convert the above information into a format suitable for presentation to the public (such as HTML or XML).

How the Information will be Disseminated

The GRSM Travel Information Home Page is envisioned to include of a map with current information events icons shown on it. The user can click on map icons to bring up the specific information related to that icon (e.g., construction, weather, closure, incident, or event). The icon information shows the event type, including location (road and direction), a short description (e.g., accident, fog, road construction), resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

In addition to the above "main map", it would also be possible to click on text listings of these same event types, and bring up pages which list the particular event type, including location (road and direction), type of event, resulting condition (road open, closed, restricted to one lane, congested, etc.) time it occurred, and expected duration.

Future expansions to this site would include icons for video and traffic data information, which when clicked, would bring up either a video image or traffic information for a particular location.

While this feature would not be part of this initial project, the capability to add this feature in the future should be incorporated.

The National Park Service website currently provides roadway closing information. Hyperlinks to the NPS website could be provided for this traveler information website. Conversely, this traveler information website could be linked to or from the NPS home page for GRSM. It is recommended that the information on road closures is shared with the NPS-GRSM main page and traveler information page.

This project will include up the 3 interfaces to allow GRSM to disseminate information to others.

Related Actions and Procedures to be Executed or Employed

Project 3.1 is responsible for generating the information to be displayed on the Traveler Information Web Page. It is expected that updates will occur during normal working hours, with the exception of emergencies or specific conditions.

It is recommended that GRSM consider procuring Projects 3.1 (ATIS Backbone Data Server and 8.1 (Early Start Dissemination) as a single procurement, with an aim to assure compatibility and interoperability between data collection, processing, and information dissemination.

Project Implementation Phases:

- Requirements and Procurement Document Development: A set of detailed functional requirements for initial website deployment shall be developed as the basis for system integrator procurement, in conjunction with Project 3.1 activities. This will include testing, training, documentation, warranty, and system software/hardware support requirements. The functional requirements for the web-based dissemination system will be developed by EFL or the GRSM-selected technical consultant.
- Installation and Integration: A system integrator is to be retained by GRSM to produce and integrate an Internet website, which meets the detailed functional requirements.
- Operational Support: The system integrator is to be retained by GRSM to provide hardware and software support services for the website.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Not relevant to this project, since it is centrally-located and relies on the Internet.
- Communications challenges – Initial challenge will be in interfacing with other systems – use of secure Internet access is preferred to dedicated high-speed links due to cost and improved Internet-based capabilities which do not require dedicated connections.
- Utility challenges – Utility challenges is not an issue for this project.
- The ability to balance all the theme areas (visitor experience with preservation with improving operations and safety, etc.) – Ability to provide timely traveler information to the public through this effort will help enhance the visitor experience.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – Operations and resources needed for the system (including staffing to monitor and manage the system) must be identified, as with any technology deployment. System maintenance skills and capabilities require both available staff and adequate training in maintaining the various components. In this case, an operations and maintenance agreement with the system integrator is recommended.
- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – Not relevant to this specific project.

- Many deployments require appropriate levels of information sharing among providers – The ability to provide information to state DOT's and other agencies may be desirable. The use of national ITS standards for information format (e.g. Traffic Management Data Dictionaries) will ensure the availability of the data in interoperable format.
- A high degree of agency/community cooperation and collaboration –It is desirable to share the ATIS information with gateway communities to fully realize the complete potential benefits of the ATIS system. The use of national ITS standards for information format (e.g. Traffic Management Data Dictionaries) will ensure the availability of the data in interoperable format. The individual data interfaces with each community are not covered under this project; however, having the data available in the standard format will facilitate such interface.
- Concurrence on the types of information to be shared – Use of national ITS standards related to the ATIS and Traffic Management Data Dictionaries is vital to ensure the future integration of the systems with real-time information mediums such as 511, wireless, websites, etc. Utilization of the national ITS standards for information formats will reduce the complexity of interfacing with TDOT and NCDOT for statewide/regional ITS information sharing.
- Concurrence on the types of strategies to employ – Not relevant to this project
- Location of ITS field equipment – Not relevant to this project.
- Deployment costs – see project costs below
- Operations and maintenance costs – Operations and maintenance costs vary based on the system configuration, the level of custom software, and the level of sophistication.

Implementation Requirements:

- Operations and maintenance strategy – Recommended for system integrator to provide software / hardware maintenance for website throughout deployment process. Recommended that vendor be retained to provide maintenance to system components for 1 to 3 year period with 2 one-year options (typical approach). As discussed above, this may be the same integrator as that for Project 3.1.
- Procurement approaches – see below.
- On-going consensus-building – Coordination between different departments within GRSM staff is critical relative to determining what is presented on the website.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Adjacent Jurisdiction/Community Involvement:

The use of national ITS standards for information format (e.g. Traffic Management Data Dictionaries) will ensure the availability of the data in interoperable format. The individual data interfaces with each community are not covered under this project; however, having the data available in the standard format will facilitate such interface.

Proposed Locations

It is proposed the public Internet server be located adjacent to the ATIS Data Backbone Server and on the same network; optionally. Depending on the proposed system integrator the Internet Server could be remotely located and supported provided there is a dedicated access for information from the ATIS Server, either through Virtual Private Network (VPN) access over the Internet or a dedicated data link.

Estimated Quantities

Proposed project would consist of an Internet Server capable of supporting at least 20,000 concurrent hits (typical) to the website providing the features described above, as well as all incidental equipment required to network this server with the ATIS Backbone Data Server developed in Project 3.1 (either at the GRSM operations facility or remotely). Up to three (3) data interfaces may be implemented.

Project Cost:

The table below provides a planning level estimate of cost for this proposed project concept, utilizing the USDOT's ITS cost database (http://www.itscosts.its.dot.gov) as a basis.

Early Start Project 8.1 – Initial Internet-Based Dissemination Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[7]
Requirements and Procurement Document Development	Procurement documents to be developed, including functional requirements, for Internet server	1	Lump Sum	$25,000	$25,000
Hardware for Internet server	Includes Internet Server	1	Lump Sum	$8,000	$8,000
Software for Internet Server	Includes off-the-shelf software map database and user interface, as well as web development environment	1	Lump Sum	$40,000	$40,000
Integration for Internet Server	Includes all software customization and integration with ATIS Server	1	Lump Sum	$60,000	$60,000
Component Funding Request					**$133,000**

Agreements

Project 8.1 was identified as the only selected early start project that could require agreements, but the agreements do not have to be in place for 8.1 to move forward. As the GRSM ATIS link or connects with various sites and/or agencies or external entities, the specifics of the use of information will need to be established prior to the link being established.

Currently GRSM has an established and in-place agreement with NCDOT regarding sharing of information on NCDOT's 511 telephone system. There is also a link to the GRSM website on NCDOT's 511 website.

[7] Costs derived from the ITS Unit Cost Database – 7/31/06 plus other similar projects.

Prior to GRSM information being distributed on TDOT's 511 system, a written agreement should be established. It is recommended that GRSM staff reference the GRSM ITS Architecture for guidance on what information to share (and address in the agreement).

Procurement Approach

The procurement approach for this project will be very similar to the procurement approach for project 3.1. In fact, there may be an advantage to combine the procurement specifications into one RFP if GRSM decides to implement these two projects together.

In stage one, GRSM can either use internal resources (GRSM or EFLHD staff) or hire an engineering consultant to develop an RFP including set of detailed functional requirements for initial website deployment as the basis for system integrator procurement. This will include testing, training, documentation, warranty, and system software/hardware support requirements.

In the second stage, GRSM will release the RFP developed in the first phase to seek competitive offers to provide system integrator services. GRSM or EFLHD staff or the engineering consultant hired for the first phase will be involved in the review of the proposals, selection of vendor, and the contract performance oversight.

As an additional option, the procurement for this project can also be handled by awarding a contract extension, based on mutual negotiations, to the contractor/vendor selected for project 3.1.

Early Start Project 9.1 – Implement Upgraded HAR

Project Concept Supported:

Project Concept 9 – Upgrade/Replace AM Radio Frequency 1610 Stations

Project Type: Implementation

Project Description:

The existing HAR system will be upgraded with an upgraded HAR system to possibly allow for dial-up HAR message changes and to expand the current area of coverage. Determination will be made as to whether or not dial-up capabilities exist at each current/existing HAR location.

The latest HAR technology will be considered in an aim to allow park authorities to remotely program and disseminate information. GRSM's updated HAR system will include intelligence – in that it will be able to detect and identify when the ATIS database threshold has changed and automatically update the messages on the HAR. The system will include message storage capabilities for pre-recorded HAR messages. Whether there are adequate communication capabilities at each site, each upgraded system will contain this capability. Enhancements to the GRSM communication capabilities may be made in the future – when they exist, the automated HAR systems will hopefully be ready to operate in the automated mode.

When appropriate, GRSM should consider deploying a fully automated HAR system once all other identified projects are deployed.

Detailed Operational Strategy

<u>Information to be Obtained</u>

Information which is contained in the ATIS Backbone Data Server (Project 3.1) will serve as input to this project. In addition, recording messages to be included in the message data store will need to be recorded.

<u>How the Information Will Be Processed</u>

The HAR system will be integrated with Project 3.1 – ATIS Backbone. The upgraded HAR system will detect changes to information entered in the ATIS Backbone. When changes are detected or thresholds have been reached (this will require the operator imputing information into Project 3.1, manually, will click on a check box to indicate the change to the HAR message set) the HAR system will automatically transmit updated messages to the HAR systems throughout the park. Periodic time and date stamps on the HAR will be upgraded if no changes in information are detected.

<u>How the Information will be Disseminated</u>

The GRSM upgraded HAR will be disseminated via telephone/dial-up capabilities to the transmitters. Travelers will obtain the information when they tune to the appropriate AM radio frequency on their radios.

<u>Related Actions and Procedures to be Executed or Employed</u>

Project 3.1 will be responsible for compiling the information that will be assessed to determine when a message needs to be changed or upgraded. Pre-recorded messages will be broadcast in a

pre-determined message format/template when there are no changes or travel impacts to broadcast.

Project Implementation Phases:

- Planning Phase – GRSM or EFL to (or GRSM/EFL to procure consultant services to):
    - Assess existing transmission/tower locations and other communication options near the currently located HAR field equipment within the park for communications, line of sight, etc.
    - Assess power capabilities at each current HAR location.
    - Evaluate GRSM staff capabilities to establish / operate / maintain the system
    - Develop a concept of operations specific to HAR – this will address automation, communication, and power issues.
- Design Phase – GRSM or EFL to (or GRSM/EFL to procure consultant services to):
    - Develop requirements and procurement documents to procure necessary HAR equipment.
    - Issue ad to procure the services of a HAR system provider/ integrator/ vendor.
    - Perform IV&V alongside the HAR vendor.
- Installation Phase – HAR system provider/integrator to deploy (install, integrate, and test the components and the system) and test the upgraded HAR equipment.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Providing/placing new HAR stations at same locations as existing eliminates any additional impact on visual aesthetics of the park.
- Communications challenges – If adequate communication capabilities are not currently in place at an existing HAR field location, no additional communications will be installed.
- Utility challenges – Existing HAR locations are assumed to have power available at each site. An assessment will need to be conducted to determine what is available to each site.
- The ability to balance all theme areas (visitor experience with preservation with improving operations and safety, etc.) – By providing more information to park visitors, this project will enhance the visitor experience. No new locations of HAR stations or towers ensure minimal impacts on park resources. Being able to send messages to the HAR stations without having to travel to the sites, enhances the utility of this system, reduces the demand on park ranger's time, and reduces the safety threat of having to travel to the HAR sites to change messages.
- Lack of available support staff to maintain a manual system that requires frequent updates (of real time traffic conditions) – This project will establish the basis for GRSM to have automation or central control of message changes for the HAR system, thus, limiting the number of staff members required for operations. Staff capabilities to operate and maintain any changes to the existing system will need to be assessed to determine impact on current operations.
- Unique to GRSM, the park's natural environmental conditions may limit options to traditional utilities (i.e., too many cloudy days for solar power) – see also "Utility Challenges" above.
- Many deployments require appropriate levels of information sharing among providers – Not applicable to this project – since it focuses on distribution of information within the park.
- A high degree of agency/community cooperation and collaboration – Not applicable to this project – since it focuses on distribution of information within the park.
- Concurrence on the types of information to be shared – Not applicable to this project – since it focuses on distribution of information within the park.

- Concurrence on the types of strategies to employ – Not applicable to this project – since it focuses on distribution of information within the park.
- Location of ITS field equipment – Not applicable to this project – since no new equipment locations will be proposed.
- Deployment costs – Please see project costs below
- Operations and maintenance costs – Operations and maintenance costs vary based on technologies deployed.

Implementation Requirements:

- Operations and maintenance strategy – assuming that communication capabilities are present at the current HAR field locations and that a message store is procured with the other components of the HAR system, the long-term operations and maintenance requirements for GRSM will be minimized. Otherwise, operations and maintenance of the system will be the same as it currently is (updates to messages are only made when a ranger visits a HAR site and manually changes the message).
- Procurement approaches – Procurement for the HAR system and design elements can be done using competitive bidding process. Any existing contracts with adjacent communities, agencies, or Federal Highway Lands Division can be investigated for potential use. It is recommended that the system concept development be completed prior to procurement of system integrator services.
- On-going consensus-building – Coordination between different departments within GRSM staff is critical. Not as relevant to this project from the perspective of other agencies, since the HAR focus is within the park.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Proposed Locations

The HAR server will be located adjacent to the ATIS Data Backbone Server (3.1) – at a minimum, it will be the same network as the ATIS Data Backbone Server. The HAR transmitters will be located in the in the same location as the current HAR transmitters (the new transmitters will replace the old ones).

Estimated Quantities

This project consists of an HAR Server, HAR software, new HAR transmitters, and a HAR message data store capable of supporting up to 4 hours of messages.

Project Cost:

The table below provides a planning level estimate of cost for this proposed project concept.

Early Start Project 9.1 – Implement Upgrade HAR Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[8]
Requirements Development	Consultant to develop operational, performance, and system requirements for input into procurement documents (may be combined with other early start efforts to gain economies of scale)	1	Lump	$25,000	$25,000
Design and Training	System Integrator, possibility to be combined with other early start integration efforts	1	Lump	$50,000[9]	$50,000
Highway Advisory Radio – 10 Watt System	Includes processor, antenna, transmitters, battery back-up, cabinet, rack mounting, lighting, mounts, connectors, cable, and license fee.	12	Each	$32,000	$384,000[10]
Hardware for Traffic Information Dissemination (HAR)	Includes 1 workstation (combine with other HW purchases).	1	Each	$4,000	$4,000
Software for Traffic Information Dissemination (HAR)	Software	1	Lump	$22,000	$22,000
System Integration and Testing	Integration and Testing	1	Lump	$10,000	$10,000
Component Funding Request					**$495,000**

[8] All cost from the ITS Unit Cost Database – 7/31/06 unless noted.
[9] Cost based on previous experience, accurate cost determination will depend on final/detailed scope
[10] Total cost IF all 12 stations are replaced.

Early Start Project 18.1 – Parking Information System – Initial Site

Project Concept Supported:

Project Concept 18 – Advanced Parking Management

Project Type: Implementation

Project Description:

An Early Start parking management system project is recommended to be deployed at the Sugarland Visitor Center parking lot. GRSM will procure the services of a parking management consultant to assist GRSM in the project management design – developing all desired messages to be displayed to the motorists and what actions to take when the lot is full – deployment, operational support, and evaluation/lessons learned report preparation. The early start parking management system hardware and software, when procured, will include parking access traffic count detection, along with small variable message signs along the road indicating the parking availability in advance of the parking lot. Currently available power and communications will be utilized in this deployment. The basic parking management design of the Sugarland Visitor Center parking system will be evaluated for possible future deployments of this project at other congested parking locations (typically near trailheads and in the Cades Cove area).

Detailed Operational Strategy

<u>Information to be Obtained</u>

The following shall be obtained through this project:

- Quantitative traffic count data at access points in and out of the identified parking facility, "zeroed out" automatically at midnight every day, allowing for estimation of available parking spaces.

Placement of loops or other (non-invasive) detection is to be located at parking lot entrances, with small, well disguised equipment cabinets (e.g., NEMA Type B enclosures) mounted on pedestals at least 10 feet behind the driveway edge. Count data shall be collected continuously.

<u>How the Information Will Be Processed</u>

Quantitative count data would be compared with total capacity of the parking facility and estimated spaces available would be determined.

<u>How the Information will be Disseminated</u>

The information on estimated spaces available (or GRSM-identified message regarding parking availability) will be displayed on small variable message signs (VMSs); possibly small VMS modules inserted into static parking guide signs. The data may also be available to support other early start projects (Concepts 3 and 8), using standardized center-to-center or local area network interfaces (e.g., XML – if appropriate communications are in place at Sugarlands parking) between the components developed under this project and future project components developed in the short term (0 to 5 years).

Related Actions and Procedures to be Executed or Employed

To implement the above elements, power will need to be available. Electric power would either draw on existing power drops or would require either stand alone batteries or solar-charged batteries. With solar power an issue in many areas of the park due to limited exposure to sunlight, care should be taken in addressing this option. Communications with a central control facility is not proposed at this stage, but would be deployed under future project stages in conjunction with other Project Concepts identified in this overall ITS Plan for GRSM. If existing communications are available, it is recommended that the parking management system information be transmitted to the GRSM headquarters/operation center.

Project Implementation Phases:

- Design Phase
  - Procure the services of a parking management deployment consultant to finalize GRSM parking management system design needs (functional and operational requirements), procurement and deployment of the hardware and software, operational assistance, and development of a lessons learned report to detail recommended changes to the system for consideration of GRSM staff for wide-spread parking management deployment throughout GRSM. The consultant will perform a power and communications assessment prior to development of the system design needs. Functional and operational requirements include:
    - system requirements and specifications documents
    - field design plans, including control schematic and layout of detectors, control devices and parking variable message signs
    - requirements for testing and installation as part of the equipment procurement process.
  - The GRSM-recommended parking management operational concept will be used to procure and deploy the necessary equipment.
- Installation Phase – this phase includes integration to the data server (if communications are available) and testing of the system, including review of contractor submittals, independent verification and validation testing, and final acceptance based on the design documents.
- Operations and Assessment Phase – The consultant will work with GRSM staff during the early operations of the system and will conduct training on system components with appropriate GRSM staff. In addition, the consultant will assess and prepare a lessons learned report that address the steps necessary to deploy parking management at the rest of the parking facilities within GRSM.

Implementation Barriers:

- The desire to minimize visual disruption of the park – Electronic signage and controller cabinets will cause some degree of disruption but can be designed so they are less obtrusive and harmonize with the surroundings (e.g. either dark green or brown colored cabinets and poles; possibly with variable signs incorporated within standard signage).
- Communications challenges – It is possible that the early start parking management system be a stand-alone installation. If this is a stand-alone deployment, the only communications will need to be between the detectors, cabinets, and variable message signs. Connectivity of this parking management system to the central data server will require existing and appropriate communications at the site. Additional communications connectivity is not a part of this early start project if it does not currently exist.
- Utility challenges – Power would rely on existing power connections as available. If it is not available, a power assessment will need to be conducted to determine how to best

power the field devices. Solar generation and/or batteries will be considered. Use of solar power must include the level of sun which is available at the Sugarlands parking lot – and also the aesthetics of such equipment.

- A high degree of agency/community cooperation and collaboration – Initial project will not require coordination with other agencies.
- Concurrence on the types of information to be shared – Initial project will not require concurrence on the types of information to be shared with other agencies. Parking information will be incorporated with Project Concepts 3 and 8 when appropriate communications modes exist.
- Concurrence on the types of strategies to employ – Initial project will not require concurrence with other agencies.
- Location of ITS field equipment – Locations of traffic detection stations and signage, as well as electronics to support operation of the system will need to be assessed as an integral part of this study.
- Deployment costs – see project costs below
- Operations and maintenance costs – Operations and maintenance costs of parking management system need to be provided for within annual GRSM budgets.

Implementation Requirements:

- Operations and maintenance strategy – Recommended that equipment vendor be retained to provide maintenance and upgrades to system components for 1 to 3 year period with 2 one-year options (typical approach), as well as provide training to GRSM roadway maintenance staff on definition of problems and corresponding actions needed.
- Procurement approaches – Procurement should be based on technical proposals which best satisfy the requirements, after which negotiations for price could occur. While there is roadside equipment implemented under this project, the system may very well be tailored for this application, and may or may not be purely "off the shelf".
- On-going consensus-building – Coordination between different departments within GRSM staff is critical. Not as relevant to this project from the perspective of other agencies, since the data collection and information display is focused within the park itself.
- Funding – The primary source for funding this project will be the Federal Lands Highway Program. Other sources of funding include any specific donations, and inclusion of installation items under construction projects as line items.

Adjacent Jurisdiction/Community Involvement:

Involvement with adjacent jurisdictions/communities is not necessary for this specific project.

Proposed Locations

Initial location is proposed to be the parking facility at Sugarland Visitor Center.

Estimated Quantities

Approximately 6 detectors will be required along with 2 parking variable message signs (PVMS). Two to three cabinets may be required with communication between the detectors and the central parking control cabinet, with calculation of space availability done using a microprocessor controller (off-the-shelf or custom developed firmware), which in turn communicates with the PVMS

Project Cost:

The table below provides a planning level estimate of cost for this proposed project concept.

Early Start Project 18.1 – Parking Information - Initial Site Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Item Cost[11]
Detailed Design	Design Plans for improved parking management system, including power and communications between devices, and system requirements.	1	Lump Sum	TBD	$[12]60,000
Detection	6 detectors, transceiver, cabinet, electrical service and pole.	1	Lump Sum	$18,000	$196,000
Parking VMS	Static guide sign with variable message module for number of spaces	2	Each	$10,000	$[13]20,000
Component Funding Request					**$276,000**

[11] Costs derived from the ITS Unit Cost Database – 7/31/06 unless noted.
[12] Cost based on previous experience. Cost will depend on selection of technology and detail design requirements including location, quantity, and functional requirements
[13] Cost based on previous experience. Cost will depend on selection of technology and detail design requirements including location, quantity, and functional requirements