Research Report
KTC-04-14/SPR 241-02-1F

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MAINTENANCE AND OPERATIONS PLAN FOR INTELLIGENT TRANSPORTATION SYSTEMS IN KENTUCKY

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Maintenance and Operations Plan for Intelligent Transportation Systems in Kentucky

by

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in cooperation with

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16. Abstract

This report presents a Maintenance and Operations Plan for Intelligent Transportation Systems (ITS) in Kentucky. It was developed using substantial stakeholder input and provides recommendations and specific strategies for supporting and coordinating ITS maintenance and operations activities throughout the Kentucky Transportation Cabinet.

A literature review and national survey helped to identify other states and urban areas that had already completed work on ITS maintenance and operations. From this information, best practices were developed that represented the lessons learned and practices implemented (or suggested for implementation) by these states. Another survey was conducted to determine the current state of ITS maintenance and operations in Kentucky. In addition, a stakeholder forum was held to identify problems and potential solutions related to ITS maintenance and operations. The following tasks were accomplished as part of this project: a literature review and national survey; development of best practices; assessment of current operations; a stakeholder forum, and a development of the ITS maintenance and operations plan are included in this report.

Based on the best practices, Kentucky's ITS maintenance and operations assessment survey, and data from the stakeholder forum, 41 specific recommendations were developed. These recommendations were organized into the following categories: planning/management of maintenance and operations; coordination and communications; documentation, tracking, monitoring, and evaluation; procurement; staffing; training; facilities and equipment; funding; and contracting.

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EXECUTIVE SUMMARY

This report presents a Maintenance and Operations Plan for Intelligent Transportation Systems (ITS) in Kentucky. It was developed using substantial stakeholder input and provides recommendations and specific strategies for supporting and coordinating ITS maintenance and operations activities throughout the Kentucky Transportation Cabinet.

To provide direction for this project, a small group of Kentucky's ITS stakeholders was assembled. This group, referred to as the Study Advisory Committee (SAC), was established in July of 2001. The SAC helped to define the following tasks that would be accomplished as part of this project.

Task 1: Literature Review / National Survey
Task 2: Development of Best Practices
Task 3: Assessment of Current State of ITS Maintenance and Operations in Kentucky
Task 4: Stakeholder Forum
Task 5: Development of the ITS Maintenance and Operations Plan

The literature review and national survey helped to identify other states and urban areas that had already completed work on ITS maintenance and operations. States with information pertinent to the development of Kentucky's ITS Maintenance and Operations Plan included: Arizona, Arkansas, California, Colorado, Florida, Kansas, Maryland, Minnesota, New Hampshire, Oregon, Pennsylvania, Texas, and Utah. The best practices were developed from the findings of the literature review and survey, and represent the lessons learned and practices implemented (or suggested for implementation) by these states. Some of the best practices documented within the report include: documenting current activities, developing and maintaining a cost database, analyzing staffing requirements, developing a training program, prioritizing needs, and developing and maintaining a spare parts inventory.

Next, another survey was conducted to determine the current state of ITS maintenance and operations in Kentucky. The survey was distributed via email to the person (or persons) identified as a primary point-of-contact for each ITS project in Kentucky. Some of the ITS equipment identified for maintenance and/or operation included: traffic cameras, dynamic message signs (DMS), traffic detectors (loop, radar, or video), traffic signal systems, commercial vehicle electronic clearance equipment, road weather information systems (RWIS), computers, specialized software, and a variety of communication systems.

The primary purpose of the survey was to identify current ITS practices in Kentucky with regard to maintenance and operations. Information gathered from the surveys included: what is being done in terms of maintenance and operations, who performs these activities, who oversees the projects, how are maintenance and operations activities documented and tracked, and what cost is associated with these activities. Findings from the state survey included:

- The type of maintenance performed varies greatly from project to project. Each ITS project is managed in a unique way and therefore maintenance is performed in different ways with different levels of priority.

- For most projects, primary responsibility for maintenance lies with a qualified contractor. The two most significant exceptions to this rule are the coordinated traffic signal systems and the portable DMS.

- For many projects, primary responsibility for operations lies with in-house resources. However, contractors are still utilized for certain projects where the expertise is not available or where there is not adequate manpower.

- The ITS Team within the Central Office Division of Traffic Operations oversees the development and implementation of all ITS projects in the state. The management of many of these projects is at the district level, with assistance provided by the ITS Team as needed or requested.

- In-house maintenance activities are documented using the Operations Management System (OMS). However, the activities being documented are generally the more "traditional" road maintenance activities of the Kentucky Transportation Cabinet. Many of the ITS maintenance activities are still not being documented.

- The cost of maintaining and operating ITS equipment is often not known, particularly for the work that is done in-house.

- Spare parts are maintained on a project-by-project basis; there are no established statewide criteria for maintaining a spare parts inventory for specific ITS equipment.

- Some of the in-house staff performing maintenance and operations for the ITS projects do receive specialized training. However, training is often acquired through on-the-job experience.

Another part of the survey aimed at identifying specific maintenance and operations problems. Nine maintenance-related problems and twelve operations-related problems were identified through the surveys.

A stakeholder forum was also used to identify problems and potential solutions. The 36 stakeholders in attendance were divided into three groups, and each group focused on two questions: 1) "What are key issues or problems related to the maintenance and/or operations of Intelligent Transportation Systems?", and 2) "What are some strategies or potential solutions to address these issues?". The key issues and problems identified included such topics as: training, system architecture and standards, funding, understanding the cost and benefits of ITS, maintenance support resources, coordination and responsibility, and staffing levels. For each of the problem topics, four to twelve strategies or potential solutions were identified.

Based on the best practices, Kentucky's ITS maintenance and operations assessment survey, and the data from the stakeholder forum, 41 specific recommendations were developed. These recommendations were organized into the following categories: planning/management of maintenance and operations; coordination and communications; documentation, tracking, monitoring, and evaluation; procurement; staffing; training; facilities and equipment; funding; and contracting.

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INTRODUCTION

Background

Intelligent Transportation Systems (ITS) technologies offer the promise of safer and more efficient travel, with the capability to greatly enhance the capacity and effectiveness of the existing surface transportation network. However, simply installing new technologies does not automatically result in a safer and more efficient system. Even the best technologies will have limited effectiveness if they are not properly operated and maintained.

Throughout the early years of ITS deployment, the emphasis was on getting systems deployed, often with little or no attention given to how the systems would be maintained and/or managed. The structure, processes, and expertise of traditional state transportation agencies were focused on highway construction projects, not on deployment and operation of high-technology systems. ITS projects are often interdisciplinary, requiring cooperation and communication among multiple agencies. These projects also involve rapidly changing technologies, creating a need for state agencies to be flexible and agile.

Within the Kentucky Transportation Cabinet, responsibilities for ITS maintenance and operations activities are divided among multiple divisions. This creates the potential for redundancy and inefficiency, or for certain items to "fall through the cracks." It is not always intuitively obvious how tasks and responsibilities should be allocated and how activities should be coordinated. Deploying new technologies can place additional burdens on the Transportation Cabinet's District Offices, which are already challenged to meet their workloads with limited staffing. Also, most Cabinet employees lack the specialized training required to maintain ITS technologies. When maintenance is not properly performed, the results can include diminished system performance, equipment failures, and increased life-cycle costs.

Objectives

The primary objective of this study was to involve ITS stakeholders throughout Kentucky in the development of an ITS Maintenance and Operations Plan. The purpose of the Plan is to provide recommendations and specific strategies for supporting and coordinating ITS maintenance and operations activities throughout the Transportation Cabinet.

As part of the Plan development, it was necessary to investigate the costs associated with maintaining and operating Kentucky's ITS hardware and software, and then to develop recommendations for better identifying and minimizing those costs.

Another key element of the Plan development was to review and assess the work performed by other states and regions. This review was used to identify "best practices" in ITS maintenance and operations. These best practices were then incorporated into the recommendations for Kentucky.

It is hoped that implementation of the recommendations developed under this study will allow the Kentucky Transportation Cabinet to make the most effective use of scarce resources. Interagency communications will be clear and effective, and the allocation of responsibilities will be logical and clearly delineated. System maintenance will be performed at the optimum intervals, by people with the proper expertise and training. As a result, the effectiveness of existing and new ITS systems will be maximized, thus providing a high level of benefits to system users.

Maintenance and Operations of Intelligent Transportation Systems

State and regional transportation agencies are quite familiar with the topic of maintenance. It has long been the responsibility of these agencies to maintain the roadway itself, along with the various elements of the roadside environment (e.g., landscaping, signs, vegetation, fencing, lighting, etc.). With the growth that has occurred in the number and sophistication of traffic signal systems, many transportation agencies have developed capabilities to maintain these traffic signals, along with their associated sensors and controllers.

Despite this familiarity with maintenance, transportation agencies still face significant challenges with respect to operating and maintaining ITS technologies. These technologies, by their very nature, tend to be "leading edge." This means that there is no maintenance history and there are no established maintenance procedures. New procedures must be developed, and new skills and expertise are needed to perform these procedures. Specialized tools and equipment may be required, along with replacement parts and components. In addition, the responsibility for maintaining ITS technologies often falls on personnel who already have their hands full with other responsibilities. All of these factors combine to make the maintenance of ITS technologies a major challenge for transportation agencies.

Here are some of the specific factors that tend to hinder the maintenance of ITS technologies.

1. There is often a lack of adequate staffing to handle the increased responsibilities of maintaining ITS technologies.

2. The responsibilities for maintaining ITS technologies are not always clearly defined in the organizational structure.

3. Personnel within the transportation agency often do not have the training and/or technical expertise needed to maintain new and sophisticated systems.

4. New systems are sometimes still in the "experimental" stage, which can result in frequent failures and a high demand for maintenance.

5. For new systems, there may be a lack of adequate documentation, such as established maintenance procedures, spare parts lists, as-built drawings, etc.

6. Maintaining new technologies frequently requires specialized tools and test equipment that are not normally available within transportation agencies.

7. ITS deployments involve both hardware and software, so software maintenance becomes necessary.

The Process for Developing Kentucky's ITS Maintenance and Operations Plan

The first step in Kentucky's process for developing an ITS Maintenance and Operations Plan was to establish a project steering committee. This committee, formally known as a Study Advisory Committee (SAC), consisted of key ITS stakeholders within Kentucky and was organized in July 2001. A project work plan was developed, presented to the SAC, and approved the following month.

The first task in the work plan was to conduct a literature review and a survey of other states. The purpose of this step was to identify other states or urban areas that have prepared ITS maintenance and/or operations plans. Based on the results of this survey and the associated literature review, a set of "best practices" was identified and documented. These best practices represent the lessons learned and practices implemented by those states or regions that have established themselves as benchmarks in the areas of ITS maintenance and/or operations.

The next step of the process was to conduct an assessment of the current state of ITS maintenance and operations in Kentucky. This included gathering information on the current cost of ITS maintenance and operations activities in Kentucky, when such information was available. It also included a determination of how ITS operations and maintenance activities are currently allocated, i.e., who currently has responsibility for operating and maintaining the various systems. This task was completed using a survey instrument developed by the project staff. A list of all existing ITS projects in Kentucky had previously been developed for another project. Using this list, a primary point-of-contact (or system expert) was identified for each project. These system experts were then surveyed to gather information on how the ITS technologies were operated and maintained. The survey also provided an opportunity for the system experts to identify specific issues or challenges related to ITS maintenance and operations.

To gather additional information on issues, challenges, and possible solutions, a list of ITS stakeholders throughout Kentucky was developed, and a stakeholder forum was held in February 2003. This forum used presentations, breakout groups, and facilitated exercises to identify specific issues and challenges related to maintenance and

operations of ITS technologies in Kentucky. The stakeholders also identified and assessed possible solutions to the key issues.

Finally, using input from the "best practices," the Study Advisory Committee, the survey of system experts, and the stakeholder forum, the project staff developed a set of specific recommendations related to ITS maintenance and operations in Kentucky. These recommendations were incorporated into the ITS Maintenance and Operations Plan. The Plan was initially presented to the SAC for their review and comment in May 2003. Several iterations were produced, eventually culminating in this final version.

ITS MAINTENANCE AND OPERATIONS IN THE U.S.

Literature Review and National Survey

The literature and Internet review helped to identify nine publications or articles with information relating to the maintenance and/or operations of ITS. The publications that were identified are listed below in Table 1 along with their corresponding state or region. Not all of these reports were actual maintenance and operations "plans", but they did contain some information that could be beneficial for the development of Kentucky's ITS Maintenance and Operations Plan. Topics covered in these articles included: cost/funding issues, prioritizing repairs, preventive and response maintenance, training, outsourcing, staff requirements, and equipment needs.

Publication Title	Corresponding State, Region, or Agency
"Guidelines for Funding Operations and Maintenance of ITS/ATMS" (*1*)	Texas
"TravInfo/Traveler Information Center Operations and Maintenance Manual" (*2*)	San Francisco, California
"Oregon Department of Transportation ITS Maintenance Plan: Addressing the True Maintenance and Organizational Requirements" (*3*)	Oregon
"Incident Management Systems and Strategies: Traffic Operations Center Operations Manual" (*4*)	Arizona
"PECOS – ITI Data Models" (*5*)	Arizona
"An ITS Maintenance Plan for the 494 Integrated Corridor Traffic Management (ICTM) Project" (*6*)	Minnesota
"ITS Management and Operations – ITE Adopts Recommended Practices" (*7*)	Institute of Transportation Engineers
"CalTrans District 7 TOS/TMC Maintenance Master Plan" (*8*)	Los Angeles, California
"Traffic and Incident Management System for I-95 in the Philadelphia Area" (*9*)	Philadelphia, Pennsylvania

Table 1. Literature Review Findings Related to ITS Maintenance and Operations

The national survey helped to identify other states that had prepared or were preparing ITS maintenance and operations plans. An ITS point-of-contact was identified for each state and surveyed to determine if they were aware of a plan within their state (either on a state or regional level) dealing with maintenance and operations of ITS equipment. The survey form is included in Appendix A. When a valid email address was available for the point-of-contact, the survey was distributed electronically. Follow-up phone calls were made to these people as necessary. If no email address was available, the survey was conducted over the telephone. Forty-nine states were surveyed (Kentucky was excluded), and forty-eight responses were recorded.

In reference to a state maintenance and operations plan, six states responded that they did have a plan or plans in existence, and two states responded that their plans were being developed. With regard to a regional plan within their state, two states responded that they did have a plan or plans in existence, and another two responded that there were plans under development. States that are currently working on either state or regional plans include: Arkansas, Colorado, Kansas, and New Hampshire. The completed plans that were identified are listed in Table 2 below along with the corresponding state or region. Copies of these plans were obtained and reviewed prior to the development of Kentucky's ITS Maintenance and Operations Plan. It should be noted that some of the publications obtained from other states or regions were not actually maintenance and operations "plans", but strategic plans or other types of documents that included elements of ITS maintenance and operations.

Plan Title	Corresponding State or Region
"PECOS – ITI Data Models" (*5*)	Arizona
"Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona" (*10*)	Arizona
"Strategic Plan for Early Deployment of Intelligent Transportation Systems on Interstate 40 Corridor Final Report" (*11*)	I-40 Corridor in Arizona
"California's Statewide Maintenance Manual – Chapter K" (*12*)	California
"CALTRANS District 7 TOS/TMC Maintenance Master Plan" (*8*)	Los Angeles, California
"TravInfo/Traveler Information Center Operations and Maintenance Manual" (*2*)	San Francisco, California
"Operations, Management and Maintenance Issues Paper" (*13*)	Florida
"Chesapeake Highway Advisories Routing Traffic (CHART) Intelligent Transportation System (ITS) Maintenance Management Plan" (*14*)	Maryland
"Oregon Department of Transportation ITS Maintenance Plan: Addressing the True Maintenance and Organizational Requirements" (*3*)	Oregon
"Intelligent Transportation Systems Maintenance Plan" (*15*)	Oregon
"ATMS Field Maintenance Manual" (*16*)	Utah

Table 2. Survey Findings Related to ITS Maintenance and Operations

Identification of Best Practices

The information obtained from the literature and Internet review and the national survey was used to develop a set of "best practices". These "best practices" represent the lessons learned and practices implemented by those states or regions that have established

themselves as benchmarks in the area of ITS management and/or operations. The "best practices" are summarized below.

Document Maintenance and Operations Activities

Logging maintenance activities helps a state to better understand their maintenance requirements. It also helps to associate a cost for maintenance (see below), and therefore better budget for these activities in coming years. California, Arizona, and Oregon have all recognized the need to document maintenance activities related to ITS infrastructure.

Develop and Maintain a Cost Database for Maintenance and Operations

In order to effectively budget for ongoing maintenance costs, several states have developed a cost database to track these costs. In general, the following variables may be considered when estimating an annual cost for maintenance of each ITS element: replacement cycle, warranty period, preventive maintenance, and demand maintenance. To support this effort, a log of all maintenance activities should be kept.

The following states either have a database in place or have recognized and documented the need for one: Arizona, Florida, Maryland, Oregon, Texas, Massachusetts, Michigan, and North Carolina.

The Arizona Department of Transportation's (ADOT) system is called PECOS (Performance Controlled System). The primary objective of PECOS is to help ADOT management staff keep track of all activities that are related to highway maintenance and better plan ahead based on historical data. The goal of ADOT was to develop the essential cost data models required for incorporation of ITS maintenance and operations considerations into PECOS. They wanted to have the ability to forecast maintenance and operations costs associated with both existing and planned ITS.

Some states have developed a cost database to track operations costs, in order to effectively budget for these costs also. The variables that should be considered when estimating the cost of operations include personnel and physical plant requirements (i.e., salaries, benefits, physical plant expenses, equipment, and utilities). Arizona and Maryland are two states that have done this.

Analyze Maintenance and Operations Requirements

It is important to analyze current ITS systems and elements to determine the types of maintenance and operations that are required. This is a critical first step in the development of a maintenance and operations plan, since these activities should be linked to staff requirements and associated cost. Some of the states that have analyzed their maintenance requirements include: Arizona, California, Maryland, and Oregon.

Analyze Staffing Requirements for Maintenance and Operations

A staffing plan identifies the requirements for sufficient, qualified, and experienced staff for maintaining and operating ITS systems. When developing a staffing plan, it is first important to understand the needs and intent of the system, since staff levels should be based on this. As part of the staffing requirements, qualifications and classifications should be developed for key employees. If special skills are needed or cost advantages can be obtained, contracting for maintenance and operational services should be considered.

Some of the states that have recognized the need to develop staffing requirements for ITS maintenance activities include: Arizona, California, Florida and Oregon. Oregon, in particular, has identified staffing resources – both in quantity and skill level – required to maintain ITS infrastructure, as well as the staffing resources that are currently available. The Oregon plan also makes recommendations where contracting may be most appropriate to address gaps in resource levels. Florida recommends that staffing requirements for operational activities should also be identified and analyzed.

Develop a Training Program for Maintenance and Operations Personnel

It is important to develop and maintain an on-going training program in order to provide a well-trained staff for maintaining and operating systems. This will help ensure that staff can perform the maintenance and operations duties to which they have been assigned. California's plan for the Los Angeles area identifies training requirements for staff. Florida recommends that a training program be developed and maintained.

Prioritize Maintenance Needs

Oregon has established guidelines in order to prioritize their maintenance requirements. They made two generalizations regarding guidelines developed by other state agencies: (a) devices are typically prioritized according to their relative importance to the daily operation or integrity of the system, and (b) safety-related or traffic control devices tend to have a higher priority than traveler information devices (*3*). In general, stakeholders should be involved with developing guidelines for identifying which repairs should take highest priority. Florida also recommends that prioritization be considered for maintenance activities.

Develop and Maintain a Spare Parts Inventory

Some states have developed and maintained an inventory of all ITS system components for maintenance purposes. To allow personnel to do their job in a timely manner, a spare parts inventory should be maintained. California has done this to ensure that timely maintenance can be performed. Florida has also seen the importance of developing a spare parts inventory; it was recommended as part of their maintenance program.

Develop a Maintenance Plan

A maintenance plan should be developed that addresses: maintenance requirements, staffing and resource gaps, training programs for employees, a spare parts inventory, prioritization of maintenance needs, and preventive maintenance.

A preventive maintenance plan should note all materials, equipment, and procedures that are needed to prevent problems with the element or system. A preventive maintenance program should reduce the overall demand maintenance that is necessary. Several states have seen the need to develop a preventive maintenance plan for the ITS infrastructure. The California Department of Transportation has developed a document for the Los Angeles area and the San Francisco area that includes a description of the necessary maintenance activities along with the associated staff requirements and the estimated cost for both preventive and corrective maintenance.

The Florida Department of Transportation has also recognized the need for a preventive maintenance plan. They suggest that the plan should note all required materials, equipment, and procedures for preventive maintenance. The State of Oregon has developed a preventive maintenance schedule for all ITS elements in the state. The Utah Department of Transportation (UDOT) has an ATMS Field Maintenance Manual to identify and define standards for preventive maintenance and unscheduled maintenance activities required for ATMS field devices. This Manual includes a discussion of a Maintenance Management System that allows UDOT to track devices, monitor failure histories, and recommend preventive maintenance schedules based upon the recorded failure history statistics, as well as cost and supplier detail.

Develop an Operations Manual

An operations manual should be provided for system operator reference. This is particularly relevant for traffic management systems. Several states and/or regions have developed this type of manual for their traffic management centers.

Additional General Recommendations

Other general recommendations were also identified as part of the "best practices". They included:

1. Maintain complete as-built and as-modified drawings and specifications of all system equipment.
2. Include maintenance and operations personnel in all phases of the project to ensure that their perspective is included in all phases of the system life cycle.
3. Consider maintenance and operations costs when budgeting for projects.
4. System maintenance should be given high priority to minimize liability risk.
5. Obtain an annual maintenance contract on all computers and other hardware that is not easily supported by agency maintenance staff.
6. Maintain a detailed inventory of all system components.

ITS MAINTENANCE AND OPERATIONS IN KENTUCKY

For Kentucky, a survey was conducted to determine the current state of ITS maintenance and operations. The survey was conducted electronically via email with follow-up phone interviews as necessary. A table summarizing the surveys is presented in Appendix B. The survey results are discussed in the sections to follow.

Inventory of ITS Equipment and Systems

The first step in assessing ITS maintenance and operations was to identify the ITS projects in the state and a primary point-of-contact for each project. Table 3 below shows the projects that were identified along with a primary point-of-contact and, in some cases, a secondary point-of-contact.

Project	Primary Point-of-Contact	Secondary Point-of-Contact
AIRS System	John Crossfield	Barney Leslie
Anti-Icing Bridge	Mike Calebs	Glenn Anderson
ARTIMIS	Leon Walden	Bob Yeager
Commercial Vehicle Electronic Credentialing	Tim Adams	
Commercial Vehicle Laptops / Wireless Communications	Jeff Bibb	
Coordinated Signal Systems	District Traffic Branch Managers	Telma Lightfoot
Cumberland Gap Tunnel Applications	John Crossfield	Don Breeding
Dynamic Message Signs	District Operations Branch Managers	
IFTA Clearinghouse	Rick Taylor	
IRIS Van	Jeff Bibb	
IRP Clearinghouse	Tim Adams	
I-65 Bowling Green	Scott Pedigo	Todd Morrison
NORPASS	Joe Crabtree	
Rest Area Traveler Information	Nancy Albright	David Cornett
Remote Monitoring System	Joe Crabtree	
Road Weather Information Systems	Glenn Anderson	
Transportation Operations Center	Nancy Albright	Joe Vick
TRIMARC	John Crossfield	Barney Leslie
Truck Rollover Warning System	Kenny Potts	Glenn Anderson
Weigh Station Networking	Jeff Bibb	
511	Leon Walden	Nancy Albright

Table 3. Kentucky's ITS Projects and Points-of-Contact

Most of the projects have a variety of ITS equipment that needs to be maintained and/or operated. ITS equipment within the state includes cameras, dynamic message signs (DMS), detectors (loop, radar, or video), signal systems, commercial vehicle electronic clearance equipment, road weather information systems (RWIS), computers, specialized software, and a variety of communication systems. A complete list of the equipment within each project is presented in Appendix B under the column, "Components of the System".

Description of Current ITS Practices

Types of Maintenance and Operations Activities Performed

The type of maintenance performed varies depending on the system and the equipment deployed for that system. A description of the maintenance activities for each of the projects is presented in Appendix B under the columns, "Corrective Maintenance Activities" and "Preventive Maintenance Activities".

Corrective maintenance is basically performed to repair or replace problematic equipment. Preventive maintenance is typically performed on a regular schedule in an effort to prevent the equipment from failing. The extent of preventive maintenance performed varies on a project-by-project basis. If funding and/or staffing requirements do not allow, then preventive maintenance is not practiced. The equipment is just replaced or repaired on an as-needed basis. In general, corrective maintenance is given priority and preventative maintenance is performed as time and resources allow.

Who Performs It?

Both in-house resources and contract services are used to maintain and operate ITS equipment in the state. The decision on who performs the maintenance and operations is decided on a project-by-project basis. Table 4, on the following pages, summarizes the maintenance responsibility, training, and problems associated with the ITS projects in Kentucky. For most projects, primary responsibility for maintenance lies with a qualified contractor. The two most significant exceptions to this rule are the coordinated signal systems and the portable DMS. This equipment is typically maintained by the Kentucky Transportation Cabinet's Central Office or by the District in which it resides. The I-65 Bowling Green project, the Truck Rollover Warning System, and the Weigh Station Networking project also use in-house resources for maintenance.

Table 5 summarizes the operations responsibility, training, and problems associated with the ITS projects in Kentucky. For many projects, primary responsibility for operations lies with in-house resources. However, contractors are still utilized for certain projects where the expertise is not available or where there is not adequate manpower.

Project	Maintenance			
	Primary Responsibility	**Secondary Responsibility**	**Specialized Training Required**	**Problems**
Road Weather Information Systems	Bluegrass Electric	KYTC - Central Office, ITS Team	Knowledge of computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection.	Telephone line - 75% Sensor and equipment failures - 25%
CVs - laptops / wireless communications	SAIC		Certification by the vendor.	N/A
AIRS	Northrop Grumman		Knowledge of electronics and computers; vendor training was provided at the time of installation.	Have to rent equipment to maintain system, because the equipment is not available in-house.
ARTIMIS	Northrop Grumman		Knowledge in electronics is desired, training required for all types of equipment, Fiber optic certification is required, occasionally a CDL license is required, knowledge of C, UNIX, Perl, cgi, php, HP systems and system administration is required.	
Cumberland Gap Tunnel	CGTA		They use a licensed mechanical engineer, an electronics specialist with NICET certification, electricians licensed by the Kentucky Dept. for Mines and Minerals, and maintenance personnel with welding certification.	Some unresolved difficulties with the custom software for the system.
IRIS Van	IRIS Company	KVE	Each officer is trained by the IRIS company.	None.
NORPASS	IRD	Kentucky Transportation Center	General electronics and computer skills and experience; specialized expertise in DSRC technology, antennas, and radio frequency transmission.	
Rest Area Traveler Information	Meteorlogix	Rest Area Staff	Electronic technician is preferred, do not know of specialized training.	Getting the contractor to maintain the equipment in a timely fashion.

Table 4. Responsibility for Maintenance

Project		Maintenance			
		Primary Responsibility	**Secondary Responsibility**	**Specialized Training Required**	**Problems**
Remote Monitoring System		CRS	Kentucky Transportation Center	General training and expertise in electronics; specialized training in digital and high-resolution cameras.	
TRIMARC		Northrop Grumman		Basic electronics background with vendor training for each item.	Lightning strikes, dirty camera domes from rain, snow, resets of equipment after adverse weather.
511		BeVocal and Telephone Service Provider	KYTC - Office of Information Technology	None.	None.
C.V. Electronic Credentialing		*No information available for report.*			
IRP Clearinghouse		*No information available for report.*			
Anti-Icing Bridge		*This system is not being used.*			
IFTA Clearinghouse		State of New York Technology Staff		Unknown.	Unknown.
Portable DMS	**District 1**	*No information available for report.*			
	District 2	District 2 - Repair Garage	Vendor	No training at all, most is learned by the manual or experience.	Most problems are from wear and tear because they are used a lot.
	District 3	Central Office - Traffic Operations	Central Office - Maintenance	*No information available for report.*	
	District 4	*There are no portable DMS assigned to this district.*			
	District 5	District 5 - County Crews	Safeti-Co	Common sense and basic mechanical skills.	Keyboards at times cause problems.
	District 6	*No information available for report.*			
	District 7	District 7 - Equipment Garage		General electrical trouble-shooting knowledge.	The signs contain a self charging system. If left unattended for long periods of time, the water in the batteries seems to evaporate. This can damage the batteries.

Table 4. Responsibility for Maintenance (continued)

Project		Maintenance			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Portable DMS	District 8	District 8 - Equipment personnel or County Maintenance personnel	Vendor	All other repairs have been performed by manufacturer, but having knowledgeable personnel in the Division of Equipment in Districts is imperative for continued operation of these signs.	Lack of expertise in the Division of Equipment in the district. Even if these units are purchased under a construction project and then turned over to Operations, they should be assigned to Equipment and given a number to ensure they are maintained on a regular schedule so that they will be ready when needed. Lack of responsibility for these units has been a problem.
	District 9	*No information available for report.*			
	District 10	District 10 - Traffic and Equipment personnel		General electrical, mechanical, and hydraulic system knowledge.	Normal wear and tear. Some keyboard problems.
	District 11	*No information available for report.*			
	District 12	District 12 - Traffic		Computer, electrical, and communication equipment skills.	Keeping the LED modules clean, we are in the process of building a cover over the modules.
Signal Systems	Central Office	Central Office - Traffic & Traffic Electronic Shop		Radio communication operation and installation, 170 controller operations, Wapiti w4iks software-local, wapiti w7osm software-master, translink or trafficview software, TSIS - Synchro software, Jamar board for counting vehicles, delay studies, and travel time, IMSA training and certifications.	
	District 1	*No information available for report.*			
	District 2	District 2 - Traffic		The District's signal crew attends IMSA traffic signal classes and receives on the job training.	

Table 4. Responsibility for Maintenance (continued)

Project		Maintenance			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Signal Systems	District 3	District 3 - Traffic		There is no specialized training required. All training is consistent with that needed for maintenance of regular traffic signals.	None to this point.
	District 4	Central Office - Traffic Operations	District 4 - Traffic	Radio communication operation and installation, 170 controller operations, Wapiti w4iks software-local, wapiti w7osm software-master, translink or trafficview software, TSIS - Synchro software, Jamar board for counting vehicles, delay studies, and travel time, IMSA training and certifications.	
	District 5	District 5 - Traffic		IMSA Level I & II certification, thorough understanding of signal design and controller programming.	Systems with no radio require significantly more attention due to lack of communication between signal and with office computer (remotely).
	District 6	*No information available for report.*			
	District 7	*No information available for report.*			
	District 8	District 8 - Traffic	Motorola	We were not given training on the DARCOM system. Motorola gave very limited technical support for this system. We learned on the job. Training for MDS units was given in the field by Central Office - Traffic.	The DARCOM system was being phased out of production when it was implemented. Therefore, technical support was very limited, replacement radio became harder and harder to find and repair was extremely costly. Without technical support and training, troubleshooting radio problems was limited. It was either a good radio or it had to be repaired by Motorola.
	District 9	*No information available for report.*			
	District 10	District 10 - Traffic		IMSA training and certifications and a minimum of 5 years of specialized signal technician training/experience in needed.	The existing signal system in operation has no maintenance problems other than signal system clock coordination.

Table 4. Responsibility for Maintenance (continued)

Project		Maintenance			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Signal Systems	District 11	District 11 - Traffic		IMSA (International Municipal Signal Association) Certification for Signal Technicians.	No major problems.
	District 12	District 12 - Traffic		System operation training, radio programming and operation of equipment.	
I-65 Bowling Green		Central Office - ITS Team	District 3 - Traffic	Knowledge of computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection.	Some problems with the ADDCO sign modules failing.
Truck Rollover Warning System		District 2 - Traffic		No training has been received for this system.	There were several problems and malfunctions during the time period the warranty was active. Problems included: not being able to communicate with the system, system not operating, and system transmitting faulty data. Since the warranty has expired, we have not had any serious problems. We sometimes cannot communicate with the system, but usually within a week, communication is recovered.
TOC (since the TOC has moved into a new facility, some comments may not be applicable)		Contract vendor (radio and satellite feed)	Central Office - Operations	Knowledge of the system and basic computer knowledge is necessary. Special knowledge of radio systems is required to maintain the radio.	The computers need rebooting on a regular basis. The radio system is 15-20 years old and needs regular corrective maintenance.
Weigh Station Networking		KVE - Systems Support person	Central Office - Office of Information Technology	Networking, computer setup and software maintenance.	None specific.

Table 4. Responsibility for Maintenance (continued)

Project	Operations			
	Primary Responsibility	**Secondary Responsibility**	**Specialized Training Required**	**Problems**
Road Weather Information Systems	KYTC - Central Office, ITS Team		Knowledge of Labview programming, computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection.	Very few - state office building network maintenance will sometimes interrupt operation.
CVs - laptops / wireless communications	SAIC		One day training received on the system; and one day to become NCIC certified.	Small bugs early; coverage issues have been resolved.
AIRS	Northrop Grumman		Knowledge of electronics and computers; vendor training was provided at the time of installation.	None.
ARTIMIS	Northrop Grumman		Training is required and is a minimum of 120 hours, including a written test if live recordings are made, a good speaking voice is essential.	None.
Cumberland Gap Tunnel	CGTA		Staff was trained as an obligation of the construction contractor; new personnel receive the necessary job training.	None.
IRIS Van	KVE		2 to 3 days hands-on training with IRIS company.	None.
NORPASS	Kentucky Transportation Center		Training in use of system software; familiarity with system enrollment requirements.	Lack of convenient access to credentials information for trucks that do not have Kentucky as their base state.
Rest Area Traveler Information	KYTC - Central Office, Division of Maintenance	Rest Area Staff	1. Training in the software. 2. None.	System is slow to update information due to satellite connection, requires using software that is old and not used for any other purpose now.
Remote Monitoring System	KVE Staff		General training on how to use the system.	Nighttime operation is poor due to insufficient lighting; system also generates false triggers; staffing shortages make it difficult for anyone to spend time monitoring the system.

Table 5. Responsibility for Operations

Project		Operations			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
TRIMARC		Northrop Grumman		Skill set includes: program management and fiscal control, systems engineering, computer systems administration, electrical engineering, software engineering, public communications protocol, ITS engineering, transportation planning, and civil engineering.	An extension of operational hours or further system enhancements are needed to provide 24/7 effectiveness.
511		BeVocal	Transportation Operations Center, State Police Dispatch centers, District Offices, and regional operations centers	Knowledge of how to input RCR information into the 511 system.	System has crashed once due to failure of calls to "roll-over" to a pool of spare telephone circuits.
C.V. Electronic Credentialing		*No information available for report.*			
IRP Clearinghouse		*No information available for report.*			
Anti-Icing Bridge		*This system is not being used.*			
IFTA Clearinghouse		*No information available for report.*			
Portable DMS	District 1	*No information available for report.*			
	District 2	District 2 - Maintenance and Traffic		None needed, just follow the directions in the manual.	Transporting them is probably the only problem because the vibration of pulling them down the road can lead to loose connections with wiring.
	District 3	District 3 - Maintenance	Central Office - Traffic Operations	*No information available for report.*	
	District 4	*There are no portable DMS assigned to this district.*			
	District 5	District 5 - Foreman, DME, TEBM and Technicians		Ability to read manual and type. Following instructions is helpful.	They are still not able to use remote access with signs. Problem could be with laptop, modem, or software. A possible solution is to purchase ADDCO laptops, which are built to use with signs.
	District 6	*No information available for report.*			

Table 5. Responsibility for Operations (continued)

Project		Operations			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Portable DMS	District 7	District 7 - Equipment Garage		None.	None.
	District 8	District 8 - Maintenance Engineers, Construction personnel, or County Superintendents		All other repairs have been performed by manufacturer, but having knowledgeable personnel in the Division of Equipment in Districts is imperative for continued operation of these signs.	Lack of expertise in the Division of Equipment in the district. Even if these units are purchased under a construction project and then turned over to Operations, they should be assigned to Equipment and given a number to ensure they are maintained on a regular schedule so that they will be ready when needed. Lack of responsibility for these units has been a problem.
	District 9	*No information available for report.*			
	District 10	District 10 - Traffic	District 10 - Section utilizes the DMS	General knowledge of unit's mechanical, electrical, hydraulic workings is required. A good understanding and review of ADDCO owner manual for operating units. Specialized training in the proper management and effective use and messaging should be made available.	Other than normal wear and tear; battery capacity in extend usage during low sunlight periods and some keypad problems.
	District 11	*No information available for report.*			
	District 12	District 12 - Letcher County Construction (Resident Engineer)		Computer knowledge.	Poor software, but 3rd revision working OK.

Table 5. Responsibi lity for Operations (continued)

Project		Operations			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Signal Systems	Central Office	Central Office - Traffic and Traffic Electronic Shop		Knowledge of the tables on the Wapiti card used the 170 controller to adjust timing. Knowledge of the purpose and functionality for a coordinated signal system.	There are sometimes communication problems with the Division of Construction. Detector loops are paved over in repavement projects or cut in road widening projects. The signal will not work efficiently until the loops are fixed. Video detection can be impaired by shadows on the roadway around or near the stop bar where it is pointing. The detector will sometimes put in a call if it picks up a shadow and thinks it's a car. Numerous objects including trees and walls depending on the location of the sun can cause shadows.
	District 1	*No information available for report.*			
	District 2	District 2 - Traffic			No.
	District 3	Central Office - Traffic		Knowledge of the tables on the Wapiti card used the 170 controller to adjust timing. Knowledge of the purpose and functionality for a coordinated signal system.	None.
	District 4	Central Office - Traffic	District 4 - Traffic	Knowledge of the tables on the Wapiti card used the 170 controller to adjust timing. Knowledge of the purpose and functionality for a coordinated signal system.	There are sometimes communication problems with the Division of Construction. Detector loops are paved over in repavement projects or cut in road widening projects. The signal will not work efficiently until the loops are fixed. Video detection can be impaired by shadows on the roadway around or near the stop bar where it is pointing. The detector will sometimes put in a call if it picks up a shadow and thinks it's a car. Numerous objects including trees and walls depending on the location of the sun can cause shadows.
	District 5	District 5 - Traffic		IMSA Level I & II certification, thorough understanding of controller program and signal operation.	Some systems do not currently have remote communication capability.

Table 5. Responsibility for Operations (continued)

Project		Operations			
		Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Signal Systems	District 6	*No information available for report.*			
	District 7	*No information available for report.*			
	District 8	District 8 - Traffic		Knowledge of 170 and radio units. Knowledge of WAPITI software required for programming. Knowledge of MDS software for programming units.	Troubleshooting the DARCOM radio system. There was no analysis software or technical support. Communication between master and office was also difficult. With the MDS units there is analysis software for troubleshooting. This should aid in keeping cost to a minimum. With Motorola, the radio unit was either working or had to be sent for repair.
	District 9	*No information available for report.*			
	District 10	District 10 - Traffic and Central Office - Traffic Operations		IMSA training and certifications and a minimum of 5 years of specialized signal technician training/experience in needed.	Incorrectly engineered signal systems and lack of follow through and coordination between Central Office and District Traffic personnel. One signal system installed utilized a radio communication system to tie signals together that never worked. Two (2) camera detection systems would not work in area that heavy fog occurs.
	District 11	District 11 - Traffic		IMSA Signal Technician Certification.	No major problems.
	District 12	District 12 - Traffic and Central Office Traffic Operations		Traffic signal system expertise.	
I-65 Bowling Green		District 3 - Operations and Construction (Resident Engineer)		Ability to set up and use dial-up Windows networking, browsers, ADDCO Brick control software. Ability to compose appropriate messages for display.	Currently, the camera images must be manually retrieved by calling the site and viewing the image on a browser. Only one person at a time can view the image and the process is cumbersome.

Table 5. Responsibility for Operations (continued)

Project	Operations			
	Primary Responsibility	Secondary Responsibility	Specialized Training Required	Problems
Truck Rollover Warning System	District 2 - Traffic		Minimum specialized training is required.	Frequent problems communicating with this system.
TOC (since the TOC has moved into a new facility, some comments may not be applicable)	Office of Transportation Operations		Training as a dispatcher and training on the software in the Center.	Training.
Weigh Station Networking	KVE - Systems Support person	Central Office - Office of Information Technology	N/A	N/A

Table 5. Responsibility for Operations (continued)

Management Structure

The ITS Team within the Central Office Division of Traffic Operations oversees the development and implementation of all ITS projects in the state. However, this group is not always involved with the maintenance and operation of these systems. The management for many of these projects is at the district level, with assistance provided by the ITS Team as needed or requested. Depending on the district and the interest level of various divisions, the project may be managed by the Division of Operations, Division of Traffic, or Division of Equipment. The larger regional projects and the statewide projects are typically managed by the ITS Team.

Documentation and Tracking

As of July 1, 2002, in-house maintenance activities are documented using the Operations Management System (OMS). However, the activities being documented are the more "traditional" road maintenance activities of the Transportation Cabinet. Many of the ITS maintenance activities are still not being documented. The Kentucky Transportation Cabinet equipment and maintenance garages and the traffic barns in each district use OMS. Both preventive and corrective maintenance are documented in this system. Employees document their maintenance activities, equipment and material usage, and labor hours. The OMS interfaces with the Kentucky Transportation's Cabinet payroll system and financial system. This system helps to track maintenance activities and their associated costs.

Maintenance and Operations Costs

The cost of maintaining and operating ITS equipment is often not known, particularly for the work that is done in-house. Some of this information is now being tracked and documented in the OMS, but the system is relatively new and is not yet fully utilized. This system should eventually help the Kentucky Transportation Cabinet better identify costs associated with maintenance and operations activities. In general, costs that are associated with out-sourced projects are more easily identified because the contractor is being paid a specific amount. However, it may still be difficult to differentiate between specific costs for maintenance and operations activities for these projects. For in-house resources, it is not easy to associate a cost with a particular project, since the resources are often used for several different projects. Costs for maintenance and operations activities are identified (if possible) for the ITS projects in Kentucky. That information is summarized in Table 6 on the following pages.

Project		Annual Cost for Maintenance	Annual Cost for Operations	Total Cost / Year
Road Weather Information Systems		$82,000 in 2002 (includes installation costs)	$21,000	$103,000
CVs - laptops / wireless communications		To be determined.	To be determined	Unknown
AIRS		<$1000	<$15,000	<$16,000
ARTIMIS		$350,000 (labor & repair costs) $150,00 (system administration)	$3.5 M	$1 Million (KYTC's share is 25% of total - $4 Million)
Cumberland Gap Tunnel		$144,000	$251,500 (raw labor cost)	$197,750 (KY is reimbursed for 50% of the total - $395,500)
IRIS Van		$2000 to $5000	$1000 to $5000	$3000 - $10,000
NORPASS		1. $61,400 (may include operations and maintenance) 2. $150,000	$150,000 (but amount reduces each year)	$361,400
Rest Area Traveler Information		Unknown (This system is leased from Meteorlogix for $85,680 - which is for standard service.)	Unknown.	Unknown.
Remote Monitoring System		$6000 to $8000	None.	$6000 - $8000
TRIMARC		~$300,000	~$1.5 million	$1.8M
511		$12000 (included in $213,000 paid to BeVocal)	$213,000	$70,000 - $82,500
C.V. Electronic Credentialing		*No information available for report.*		
IRP Clearinghouse		*No information available for report.*		
Anti-Icing Bridge		*This system is not being used.*		
IFTA Clearinghouse		*No information available for report.*		
Portable DMS	**District 1**	*No information available for report.*		
	District 2	Varies on use of DMS	Varies on use of DMS	Unknown.
	District 3	*No information available for report.*		
	District 4	*There are no portable DMS assigned to this district.*		
	District 5	$9,000	$9,000	$18,000

Table 6. Total Cost Analysis and Results

Project		Annual Cost for Maintenance	Annual Cost for Operations	Total Cost / Year
Portable DMS	District 6	*No information available for report.*		
	District 7	$5000 ($500 / DMS * 10 DMS)	$5000 ($500 / DMS * 10 DMS)	$10,000
	District 8	Unknown.	Unknown.	Unknown.
	District 9	*No information available for report.*		
	District 10	$2000 - $7500 ($400 - $1500 / DMS * 5 DMS (depending on usage))	$2000 - $7500 ($400 - $1500 / DMS * 5 DMS (depending on usage))	$4000 - $15,000
	District 11	*No information available for report.*		
	District 12	N/A	N/A	N/A
Coordinated Signal Systems	Central Office	$60,000 (5 systems)	$60,000 (5 systems)	$120,000
	District 1	*No information available for report.*		
	District 2	Cost is negligible.	Cost is negligible.	Cost is negligible. (The only monthly cost is the phone bill.)
	District 3	Not operating long enough to determine.	Not operating long enough to determine.	Unknown.
	District 4	*Refer to answers provided by the Central Office Staff for Coordinated Signal Systems.*		
	District 5	$1000 per intersection	$1000 per intersection	$2000 per intersection
	District 6	*No information available for report.*		
	District 7	*No information available for report.*		
	District 8	$3,400	$17,000	$20,400
	District 9	*No information available for report.*		
	District 10	$300 - $500	$300 - $500	$600 - $1000
	District 11	$8000 ($1000 / system * 8 systems)	$4000 ($500 / system * 8 systems)	$12,000
	District 12	N/A	N/A	N/A

Table 6. Total Cost Analysis and Results (continued)

Project	Annual Cost for Maintenance	Annual Cost for Operations	Total Cost / Year
I-65 Bowling Green	None.	Unknown at this time.	Unknown at this time.
Truck Rollover Warning System	*No information available for report.*		
TOC	Unknown.	Unknown.	Unknown.
Weigh Station Networking	N/A	N/A	N/A

Table 6. Total Cost Analysis and Results (continued)

Logistics

Spare Parts

Spare parts are maintained on a project-by-project basis; there are no established statewide criteria for maintaining a spare parts inventory for specific ITS equipment. The availability of spare parts is greatly dependent on the person or group managing the ITS project.

Training

Most of the ITS projects in Kentucky require some knowledge of computers and electronics in order to maintain and/or operate the equipment. In fact, some of the projects require very specialized knowledge of the equipment. These projects are often the ones that are outsourced to a consultant. The consultants tend to have highly knowledgeable and well-trained staff.

Some of the in-house staff performing maintenance and operations for the ITS projects do receive specialized training. However, training is often acquired on-the-job by experience. In some situations, the Kentucky Transportation Cabinet has required that the vendor supply training to Cabinet personnel prior to acceptance of the equipment.

ASSESSMENT OF CURRENT PRACTICES: ISSUES AND OPPORTUNITIES

The Process for Assessing Current Practices

The assessment of current ITS maintenance and operations practices in Kentucky depended on two primary information sources. One source was the survey of "system experts" throughout the state, as described in the previous section. The other source was the stakeholder forum held in February 2003.

The survey of system experts was sent to 36 selected experts throughout the state, requesting specific information on 21 projects. Surveys were completed and returned on 17 of the projects. The survey was deemed "not applicable" for one project, because the system was not being used. For another project, a partially completed survey form was returned. No information was received for two projects.

The primary purpose of the survey was to gather information for describing current practices. However, the survey also provided an opportunity for the system experts to identify specific maintenance-related or operations-related problems of which they were aware. Nine of the completed surveys provided information on maintenance-related problems, while 12 surveys described operations-related problems. These problems are listed below.

Maintenance-Related Problems Listed on Survey

- For the Roadway Weather Information Systems (RWIS), problems with the telephone line represent 75% of the maintenance issues, while system and equipment failures make up the remaining 25%.
- For the Auto Incident Recording System in Louisville, the agency has to rent equipment to maintain the system, because the equipment is not available in-house.
- For traffic signal systems, there are several issues, including:
    - Signal system clock coordination.
    - Limited technical support for Darcom system (was being phased out of production when implemented)—limited availability of replacements and costly repairs.
    - Time-based systems (no radio) require significantly more attention.
- For the Cumberland Gap Tunnel, there are some unresolved difficulties with the custom software for the system.
- For dynamic message signs, there is a lack of expertise in some of the districts, and there is a lack of clear responsibility for these units.

- For I-65 in Bowling Green, there is a problem with modules failing for the ADDCO dynamic message signs.

- For the Rest Area Traveler Information system, there is a problem getting the contractor to maintain the equipment in a timely fashion.

- For the Transportation Operations Center, the computers need rebooting on a regular basis. The radio system is 15-20 years old and needs regular corrective maintenance. (This comment may no longer be valid since the TOC is now in a new facility.)

- For TRIMARC, there are problems with lightning strikes, dirty camera domes (from rain and snow), and resets of the equipment after adverse weather.

Operations-Related Problems Listed on Survey

- For the Roadway Weather Information Systems (RWIS), there are very few operational problems, but State Office Building network maintenance will sometimes interrupt operations.

- For the commercial vehicle enforcement laptops in cruisers and wireless communications, there were some small bugs early. The coverage issues have been resolved.

- For traffic signal systems, there are several issues, including:
    - Some systems do not have remote communication capability.
    - There is no technical support with the Darcom systems.
    - Sometimes loop detectors are paved over.
    - Video detection systems do not always work properly.
    - Incorrectly engineered signal systems, and a lack of follow-through and coordination with districts and central office.
    - One radio communication system never worked.
    - Two video detection systems never worked in an area that had heavy fog.

- For dynamic message signs, there are several issues, including:
    - Poor software.
    - Battery capacity in low-sunlight conditions.
    - Transporting the signs can lead to loose connections with wiring.
    - Not able to use remote access with signs—problem could be with laptop, modem, or software. Possible solution: purchase ADDCO laptops, which are built to use with signs.

- For I-65 in Bowling Green, currently the camera images must be retrieved by calling the site and viewing the image on a browser. Only one person at a time can view the image, and the process is cumbersome.

- For commercial vehicle electronic screening (i.e., NORPASS), there is a lack of convenient access to credentials information for trucks that do not have Kentucky as their base state.

- For Rest Area Traveler Information, the system is slow to update information due to satellite connection. It requires using software that is old and no longer used for any other purpose.

- For the Remote Monitoring System, there are several issues, including:
  - Nighttime operation is poor due to insufficient lighting.
  - The system generates false triggers.
  - Staffing shortages make it difficult for anyone to spend time monitoring the system.

- For the Statewide Transportation Operations Center, training is an issue.

- For TRIMARC, an extension of operational hours or further system enhancements are needed to provide 24/7 effectiveness.

- For the Truck Rollover Warning System, there are frequent problems communicating with the system.

- For the 511 System, the system has crashed once due to failure of calls to "roll over" to a pool of spare telephone circuits.

Stakeholder Forum

The stakeholder forum was held on February 19, 2003, in Lexington, Kentucky. There were 36 stakeholders in attendance at the forum. After a preliminary presentation on ITS, the background of the project, and the purpose of the forum, the stakeholders were divided into three breakout groups. Each breakout group worked through a two-part exercise. For the first part, each group addressed the following question, using a "consensus workshop" process:

> ***"What are key issues or problems related to the maintenance and/or operations of Intelligent Transportation Systems?"***

Each group brainstormed issues, grouped these issues into categories, and then voted to establish the relative importance of each category.

Following a break, the groups reconvened for the second part of the exercise. Each group was assigned two or three of the highest-ranked categories from the first part of the exercise. For these categories, they were asked the following question:

"What are some strategies or potential solutions to address these issues?"

After brainstorming to identify potential solutions, the group spent some time ranking the potential solutions. Each potential solution was ranked in terms of its potential effectiveness and in terms of the amount of effort that would be required to implement the solution.

The "raw output" of the stakeholder forum is presented in Appendix C. A summary of the results is presented in the following discussion.

Results of Stakeholder Forum

As might be expected, there were several issues (or categories of issues) that surfaced in more than one of the breakout groups. Usually, the categories were given somewhat different names by the different breakout groups, but the individual issues within the category could be used to determine if the categories were really the same. The top categories of issues identified by the stakeholders were as follows. They are listed in descending order, based on the total number of votes they received in the three breakout groups.

1) Training, education, and specialized expertise

2) System architecture and equipment standardization

3) Funding for operations and maintenance

4) Identifying and understanding the costs and benefits of ITS technologies

5) Maintenance support resources (effective preventive maintenance program and procedures; manuals; tools; test equipment; etc.)

6) Coordination and responsibility for ITS maintenance

7) Adequate staffing levels

For each of these categories, the groups identified from four to twelve strategies or potential solutions. Each of these was then evaluated based on its anticipated effectiveness (or value) and the level of effort (or funding) that would be required to implement it. Based on this type of analysis, the most attractive strategies would be those that have high value and require low effort. The least attractive options are those that have low value but require high effort.

The following is a listing of the more "attractive" strategies suggested for each of the categories of issues.

1) Training, education, and specialized expertise.

    a) Identify training needs.

    b) Mandate (within contracts) that vendors for ITS equipment must provide on-going training.

    c) Conduct an inventory of the systems we have.

    d) Provide job-specific, hands-on training.

    e) Develop a program manual (including training requirements and the purpose of the system) for each of our ITS projects or systems. – High effort required

    f) Develop an operational manual for each of our ITS projects or systems. – High effort required.

2) System architecture and equipment standardization.

    a) Use local technical support. Choose vendors that can provide local support for the system. – High effort required.

    b) Require interoperability for all systems. – High effort required.

    c) Develop and implement responsive procurement procedures. – High effort required.

    d) Develop and use precise specifications when procuring ITS technologies. – High effort required.

3) Funding for maintenance and operations.

    a) Incorporate maintenance, operations, and life-cycle costs into the process for developing and implementing new projects.

    b) Lobby in Washington, DC for funding to support Kentucky's ITS initiatives.

    c) Look at options for privatizing maintenance and operations activities.

    d) Look at using grant money to support major projects, thus freeing up state resources for maintenance and operations.

    e) Undertake public support campaigns to foster support for ITS.

f) Charge utility companies for the use of state right-of-way. – High effort required.

g) Make the case to decision-makers for dedicated ITS funding. – High effort required.

h) Increase the budget for the Division of Traffic Operations to include maintenance and operations activities for ITS. – High effort required.

i) Implement toll roads with ITS technologies built-in. – High effort required.

j) Privatize the construction and operation of selected roadways. – High effort required.

4) Identifying and understanding the costs and benefits of ITS technologies.

a) Conduct user surveys.

b) Conduct outreach to users to convey to them the value and benefits of ITS technologies.

c) Conduct outreach to managers/decision-makers to convey to them the value and benefits of ITS technologies.

d) Make sure all ITS projects and systems have user-friendly hardware and software. – High effort required.

e) Provide timely and accurate information to users. – High effort required.

5) Maintenance support resources (effective preventive maintenance program and procedures; manuals; tools; test equipment; etc.).

a) Schedule maintenance.

b) Identify preventive maintenance requirements for all systems and make this information available to technicians – High effort required.

c) Have preventive maintenance items on-hand; prioritize/manage. – High effort required.

d) Support the maintenance schedule. – High effort required.

6) Coordination and responsibility for ITS maintenance.

a) Define system owner.

b) Establish guidelines for "repair versus replace" decision-making.

c) Identify maintenance needs.

d) Develop a maintenance strategy, including the level of maintenance and whether it should be in-house or out-sourced. – High effort required.

7) Adequate staffing levels.

a) Identify the needs for trained personnel and the consequences of not having the necessary personnel.

b) Outside training (e.g., vendors).

c) Cross-training.

d) More funding. – High effort required.

e) Cap issues – raise or remove the limits on number of personnel. – High effort required.

f) Career ladder potential. – High effort required.

g) Updated job classifications. – High effort required.

Follow-up from Stakeholder Forum

At the conclusion of the stakeholder forum, participants were invited to provide additional input by writing their issues or suggestions down and submitting them to the project staff. They were also invited to send in additional information via e-mail. As a result, a significant amount of additional input was received from stakeholders after the forum. Additional problems or issues that were identified included:

- A facility is needed to maintain ITS equipment.
  - The lab in the statewide Transportation Operations Center (TOC) is a good start, but we also need something similar to the traffic electronic shop.
  - The facility needs to have a ramp and sufficient space to accommodate portable message signs.
- Ensuring safety of personnel.
- Ineffective/inefficient repair processes.
  - Initially, some DMS components had to go to Canada for repair. They often spent days at customs. Having a repair location in the country has helped, but too often, it still takes time to have things repaired.
- All issues associated with facility management come in to play when a center is involved.

- How to effectively repair large, immobile items (such as fixed DMS).
- Having accurate, as-built drawings of the system and keeping them current.
- Lack of written plans and/or procedures.
- Important to hire personnel with the proper experience.
- Maintaining an education and outreach program is very important.
- For traffic management centers, 24/7 operations are needed, because problems do not restrict themselves to the core hours from Monday through Friday.
- Have system administration support, preferably on site.
- Human factors engineering needs to be considered in TMC designs.
- Under privacy issues, the value of information, and the need at times to restrict access.
    - Policies and procedures should be put in place and followed.

Additional solutions that were suggested after the stakeholder forum included:

- Make sure all personnel are aware of the safety steps that can be taken specific to the job being performed.
    - Make sure the appropriate equipment is available (vests, cones, test equipment, etc.).
    - Post procedures and perhaps have periodic refresher sessions.
- Work with the vendor and/or repair facility to determine the actual process and determine ways to streamline.
    - This may be tough to do. You may need to just plan on enough spares to cover delayed repairs.
- Have a training course on facility management.
    - May be easiest to put service contracts in place for major items (e.g. HVAC, elevators, cleaning, etc.).
- Develop procedures.
    - May require night work if roadway closures are involved. Also, they should have appropriately trained personnel to inspect these systems for fatigue, etc.
- Allocate the time to keep drawings up-to-date.
    - Insist that a development contractor provide such documents at the completion of the effort and tie a significant pay item to them for insurance. Every effort should be made to incorporate these into the next set of plans (i.e., keep one master copy pertaining to each roadway).
- Write things down.

RECOMMENDATIONS

Using the solutions and strategies that surfaced during (and after) the stakeholder forum, as well as the suggestions offered through the survey of system experts, a set of specific recommendations was developed. The project staff then worked in close cooperation with the Study Advisory Committee to refine and organize the list. The resulting list of recommendations is presented below.

Planning/Management of Maintenance and Operations

- Establish a policy that defines specifically who has responsibility for maintenance and operations for each ITS system in the state.
- Since the Division of Traffic Operations already has substantial capability (including facilities and trained personnel) for maintaining electronic equipment, assign them the responsibility for maintaining ITS equipment as well, and increase their budget accordingly.
- Establish guidelines for determining priorities for ITS maintenance. These guidelines will be used to determine which repairs will take the highest priority.
- Give a high priority to system maintenance (both preventive and corrective), so as to maximize operations and minimize liability risk.
- Develop a preventive maintenance plan that is updated annually. Identify the preventive maintenance requirements for each ITS deployment in Kentucky and schedule preventive maintenance as appropriate.
- Develop policies to guide "repair versus replace" decision-making.

Coordination and Communications

- Provide enhanced communications and coordination between central office and district offices regarding ITS projects.
- Conduct user surveys to see if systems are working properly and to see if they have value.
- Include maintenance and operations personnel in all phases of ITS projects, from inception through completion, to ensure that their perspective is included in all stages of the project.

Documentation, Tracking, Monitoring, and Evaluation

- Develop and maintain a detailed inventory of all ITS system components.

- Implement a program (or make use of the OMS) to begin documenting maintenance activities for all ITS equipment.
  - This will allow the Transportation Cabinet to begin building a history on the maintenance requirements of various ITS components.
  - It will provide a necessary input into the development of a maintenance cost database (see later recommendation).
  - It will allow for better planning and budgeting for maintenance activities in future years.
- Perform an analysis of the maintenance and operations requirements of current ITS systems.
  - This will provide an essential input for any determination of budgets and staffing levels for ITS maintenance and operations.
- Monitor the amount of resources consumed by maintenance and operations activities for specific ITS deployments. Consider upgrades or replacements for systems that consume high levels of resources.
- Where contractors are responsible for system maintenance and operation, monitor contractor performance and, where appropriate, consider replacement or other corrective actions.
- Maintain a centralized set of complete as-built and as-modified drawings and specifications for all ITS equipment.
- Develop a program manual (including training requirements and the purpose of the system) for each of the ITS projects or systems.
- Develop written maintenance procedures for all ITS equipment and systems.
- Develop an operations manual for each of the ITS projects or systems.
- Work with the vendor and/or repair facility to determine and document the actual maintenance process and ways to streamline it.

Procurement

- When procuring ITS technologies and/or software, establish evaluation criteria that give high value to ease of maintenance and operations.
- When procuring ITS equipment and/or software, mandate that the vendor must provide initial and on-going training.

- When procuring ITS equipment and/or software, develop and use precise specifications to ensure standardized equipment, interoperability, interchangeability of parts, etc.
- Make sure human factors engineering is considered in the design and procurement of traffic management centers.
- Develop and implement responsive procurement procedures.
- Include life-cycle cost in consideration of ITS alternatives during project development and system procurement.

Staffing

- Develop a staffing plan that provides for sufficient, qualified, and experienced staff for maintaining and operating ITS systems.
  - This will depend on the resource analysis described above.
  - This should ensure adequate quantity and skill level of staff.
  - This should consider contracting options where appropriate.
- Identify the consequences (including the associated cost) of not having adequate staffing resources available. Use this as justification to secure adequate funding for maintenance and operations staff.
- Ensure that a proper career ladder is provided for ITS maintenance and operations personnel.

Training

- Identify, document, and assess the training needs associated with maintaining and operating Kentucky's ITS systems.
- Develop a training program for all personnel who have responsibilities for maintaining and operating ITS equipment.
  - Use vendors to provide training where appropriate.
  - Include cross-training where appropriate.
  - Include training on safety (also post safety procedures and have periodic refreshers).
- When designing and conducting training, make sure it is job-specific and hands-on.

- In contracts for ITS equipment and/or software, mandate that vendor must provide initial and on-going training. (This is a repeat of a recommendation under "Procurement" above.)

Facilities and Equipment

- Develop and maintain an inventory of spare parts for ITS equipment.
- Identify the tools and test equipment needed for preventive and corrective maintenance activities. Make sure these items are readily available to those who perform the work.
- Develop a short list of preferred or prequalified products to provide some consistency with regard to compatibility and maintenance.
- Make sure all the appropriate safety equipment is readily available (vests, cones, test equipment, protective clothing, etc.).
- Establish a facility for the maintenance of ITS equipment.
    - Similar to (or combined with) the Traffic electronic shop.
    - Needs to have a ramp and sufficient space to accommodate portable message signs.

Funding

- Develop a cost database to allow the tracking of costs associated with ITS maintenance and operations.
    - This is closely related to the recommendation for documenting maintenance activities.
- When developing budgets for ITS projects, make sure that maintenance and operations costs (i.e., life-cycle costs) are included.
- Explore and develop alternative sources of funding for operations and maintenance of ITS systems. For example:
    - Lobby for Federal funding and state funding to support Kentucky's ITS initiatives. Look at using grant money to support major projects, thus freeing up state resources for operations and maintenance.
    - Conduct outreach to managers/decision-makers to convey to them the value and benefits of ITS technologies.
    - Look at options for privatizing maintenance and operations activities.

- Evaluate the potential for implementing toll roads with ITS technologies built into the roadway.

Contracting

- Obtain an annual maintenance contract on all hardware that is not easily supported by state agency personnel.

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(16) "ATMS Field Maintenance Manual" Transcore, Utah Department of Transportation. August 2002.

APPENDICES

Appendix A

The Kentucky Transportation Center (KTC) at the University of Kentucky is developing an Intelligent Transportation Systems Maintenance and Operations Plan for the Kentucky Transportation Cabinet. To assist us in this effort, could you please take a couple of minutes to read this brief email and answer two questions?

The purpose of the ITS Maintenance and Operations Plan is to ensure that system maintenance and operations are key considerations when implementing any ITS technology. It will provide a set of guidelines and procedures to make sure maintenance is performed effectively and without excessive cost.

The intent is for the Plan to provide a clearer understanding of the best way to allocate and coordinate maintenance and operations responsibilities within the Cabinet, thus resulting in more efficient and effective utilization of resources. As we prepare this plan we would like to review similar plans that have been developed by other states or urban areas.

1) Has an ITS maintenance and/or management plan been prepared for your state or any of your urban areas?

For State: Yes _____ No: _____

For Urban Areas: Yes:_____ (Please Specify: _____) No: _____

2) If so, how might I obtain a copy of the plan(s)?

Thank you for your time. If you have any questions or would like further information regarding this study, please don't hesitate to contact me.

Appendix B
Maintenance

Project	Components of the System	How Many Deployed?	Earliest Deployment?	Corrective Maintenance Activities	Preventive Maintenance Activities	In-House, Contract, or Both	Specific Company or Agency doing Maintenance	Maintenance Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Maintenance	Funding	Maintenance Problems
Road Weather Information Systems	Datalogger, modem, sensors	23	1990	1. Repairing sensors 2. Calling for phone line repair 3. Replacing damaged equipment	1. Cleaning Rain Gage 2. Cleaning camera lens 3. Cleaning solar radiation lens 4. Changing desiccant packs	Both	1. Bluegrass Electrical Contractors 2. KYTC ITS Personnel	1. Installs and performs primary installation and maintenance 2. Perform some maintenance and troubleshooting assistance	Knowledge of computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection	1. 765 2. 416 (ops & maintenance)	$82,000 in 2002 (includes installation costs)	State - Operations	Telephone line - 75% Sensor and equipment failures - 25%
CVs - laptops / wireless communications	Computer, satellite dishes, software, modem	33	2002			Contract	SAIC		Certification by the vendor	To be determined	To be determined	Unknown	N/A
AIRS	Controller, VCR, VCR control box, 2 color cameras, 2 microphones, sensors, signal phase detector	1	Jul-01		Replacement of microphone covers, VCR overhaul, replacement of microphone & VCR every 5 years, controller inspections every year, camera and microphone inspections every year	Contract	Northrop Grumman		Knowledge of electronics and computers; vendor training was provided at the time of installation	5	<$1000	State - Operations	Have to rent equipment to maintain system, because the equipment is not available in-house
ARTIMIS	CCTV cameras, DMS (fixed), fiber optic cable, loop detectors, radar detectors, HAR, cabinets, controllers, servers and workstations	1 system (CCTV - 15, DMS - 10, Fiber optic cable - 12 miles, loop detectors - ~170, radar detectors - 37, HAR -1, cabinets - 47)	Mar-97	1. Repair of equipment 2. Replacement of damaged or outdated equipment 3. Troubleshooting problems with the various components 4. Installation of new equipment	1. As time permits	Contract	Northrop Grumman		Knowledge in electronics is desired, training required for all types of equipment, Fiber optic certification is required, occasionally a CDL license is required, knowledge of C, UNIX, Perl, cgi, php, HP systems and system administration is required	4 full-time maintenance technicians and 1 full-time system administrator	$350,000 (labor & repair costs) $150,00 (system administration)	CMAQ (20%), National Highway System funds (60%), and FD 04 State matching funds (20%) - eventual migration to State Operations funds	

Project	Components of the System	How Many Deployed?	Earliest Deployment?	Corrective Maintenance Activities	Preventive Maintenance Activities	In-House, Contract, or Both	Specific Company or Agency doing Maintenance	Maintenance Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Maintenance	Funding	Maintenance Problems
Cumberland Gap Tunnel	DMS, CMS, variable speed limit signs, lane use signs, traffic signals, over-height vehicle detection system, CCTV, cross-passage strobe lights	1 system	1996	Replacement of luminaries and sign components	Vibration analysis and infrared surveys; circuits are merger tested on a bi-annual basis	Contract	CGTA personnel - they contract with others for preventative maintenance as necessary		They use a licensed mechanical engineer, an electronics specialist with NICET certification, electricians licensed by the Kentucky Dept. for Mines and Minerals, and maintenance personnel with welding certification	4500	$144,000	State - Operations (reimbursed 50% by Tennessee)	Some unresolved difficulties with the custom software for the system
IRIS Van	Van, infrared/thermal image camera, monitors, VHS tape system	3	May-99	IRIS company does this	Charging the system	Both	1. IRIS Company 2. KVE Staff	1	Each officer is trained by the IRIS company	10 to 20	2000 to 5000	MCSAP funds	None
NORPASS	DSRC readers (processor, transmitter, etc.), antennas, transponders, computers, WIM (one location only), truck detectors / classifiers, communications (RS-422, fiber-optic, radio frequency modem, etc.)	13 weigh stations	1993-94	Performed by IRD as needed	Daily status checks performed via remote connection	Contract	1. Kentucky Transportation Center 2. IRD	1. Status checks and oversight and support of IRD 2. System maintenance	General electronics and computer skills and experience; specialized expertise in DSRC technology, antennas, and radio frequency transmission	No KYTC time.	1. $61,400 (may include small amount of operations funding) 2. $150,000	FE-04 - 100% State Funds	
Rest Area Traveler Information	Oversized computer monitors, satellite receiver dishes, connection to satellite receiver box	32	1998	Replacing monitors as needed, occasionally the box needs remote maintenance and is performed with someone on site talking to the 'home office' to correct a downlink problem; the receiver box needs replacing less frequently	None	Both	1. Rest area staff 2. Meteorlogix	1. Daily checks and reports problems 2. Service whatever problem is reported	Electronic technician is preferred, do not know of specialized training	200 (KYTC staff)	Unknown (This system is leased from Meteorlogix for $85,680 - which is for standard service.)	State maintenance budget	Getting the contractor to maintain the equipment in a timely fashion

Project	Components of the System	How Many Deployed?	Earliest Deployment?	Corrective Maintenance Activities	Preventive Maintenance Activities	In-House, Contract, or Both	Specific Company or Agency doing Maintenance	Maintenance Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Maintenance	Funding	Maintenance Problems
Remote Monitoring System	Cameras, processor, software, loop detector, height detector, lighting, ISDN communication line	1, a second system is being deployed in Laurel County	Jul-00	Weekly status checks and fine-tuning		Contract	1. Kentucky Transportation Center 2. CRS, Inc.	1. Oversight of maintenance contract and assistance to CRS as needed 2. Status checks and corrective maintenance as needed	General training and expertise in electronics; specialized training in digital and high-resolution cameras	None	$6000 to $8000	CVISN funds	
TRIMARC	Servers (ATMS software and processing, web host, video), workstations, cameras, video coders/encoders, modems (telephone, ISDN, wireless), detectors (loop, video, radar), controllers, dynamic message signs, highway advisory radio, video production system, data radios	1 system	1998	On-site inspection and test for correct operation (reset of device, spare replacement, laboratory repair, and factory repair)	Yes, but type of preventative maintenance not described	Contract	Northrop Grumman		Basic electronics background with vendor training for each item	2080	~$300,000	Operations funds	Lightening strikes, dirty camera domes from rain, snow, resets of equipment after adverse weather
511	CARS-511 call center telephone equipment and computer work stations	1 system	2002	Maintenance for computers and telephone lines as needed	Activities are primarily preventive	Both	1. BeVocal 2. Telephone service provider 3. Office of Technology	1. CARS-511 call center equipment maintenance 2. Telephone line maintenance 3. Statewide TOC workstations maintenance	None.	Unknown, but minimal	$12,000 (doesn't include work station maintenance which if part of Office of Technology's normal duties)	FE 01 funds allocated to the Office of Technology	None
C.V. Electronic Credentialing	No information available for this report.												
IRP Clearinghouse	No information available for this report.												
Anti-Icing Bridge	This system is not being used.												

Project	Components of the System	How Many Deployed?	Earliest Deployment?	Corrective Maintenance Activities	Preventive Maintenance Activities	In-House, Contract, or Both	Specific company or agency doing Maintenance	Maintenance Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Maintenance	Funding	Maintenance Problems
IFTA Clearinghouse	No information available for this report.												
Portable DMS	Portable dynamic message signs, some communications	~70	1995	Changing out LED modules and single board computer, replace display boards, repair charging system	Battery maintenance, general lubrication of moving parts on system, cleaning LED modules, inspection of trailer	In-House	District personnel (the specific division varies depending on the district)		Computer, electrical, and communication equipment skills; knowledgeable person is imperative for continued operation of signs	Varies	Varies	Varies	Lack of expertise in the division of equipment in the district; lack of responsibility for these units
Signal Systems	Controllers, radios, modems, antenna, phone line, vehicle detectors (video or loop)	50+	Early to mid 1980s	Replacing necessary units, video and loop detectors are maintained as needed when complaints come in	Checking power supply, checking units for correct data display, checking communication, checking antenna and modem	In-House	District or Central Office Personnel (Division of Traffic)		IMSA Level I & II certification, thorough understanding of signal design and controller programming, learned by on-the-job experience	Varies	Varies	FE 04 Traffic Budget	Signal system clock coordination, technical support has been limited for Darcom system because system was being phased out of production when implemented (replacement equipment was difficult to find and repair was costly), time-based systems (no radio) require significantly more attention
I-65 Bowling Green	Dynamic message signs (semi-permanent), cameras, road weather information system	1 system (6 DMS, 1 RWIS)	Fall 2002	Check to see if modem is responding, reset if necessary; phone line troubleshooting, replacing bad sign modules, replacing cameras, replacing sign controller, replacing sign power supply, RWIS maintenance	Cleaning camera, RWIS maintenance, performing sign pixel tests	In-House	1. Division of Traffic Operations (ITS), Central Office 2. Division of Maintenance - District 3	None to date.	Knowledge of computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection	0	0	Unknown - likely operations overhead (either district or central office)	ADDCO signs modules failing

Project	Components of the System	How Many Deployed?	Earliest Deployment?	Corrective Maintenance Activities	Preventive Maintenance Activities	In-House, Contract, or Both	Specific company or agency doing Maintenance	Maintenance Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Maintenance	Funding	Maintenance Problems
Truck Rollover Warning System	Microwave sensor, controller, cabinet, phone modem, fiber optic message sign	1	16-Jan-01	Vehicle detection sensors: verify sensor operations and performance, verify the strain relief's are operational and that all the fasteners are tight Electronics interface and wiring: remove, clean and inspect circuit boards, maintain all electrical connectors, cables and components, verify ground integrity, and ensure the cards are firmly seated		Unknown - system was under warranty until Jan 2002				*No information available for report.*			
TOC (since the TOC has moved into a new facility, some comments may no longer be applicable)	Dispatch radio equipment, servers for RWIS, computers, satellite feed	1 operations center	1998	Maintenance on the radio system and computers as needed	Unknown	Both	1. Vendor 2. Company supplying satellite feed 3. Division of Operations	1. Maintains radios 2. Maintains satellite feed 3. All other maintenance activities	Knowledge of the system and basic computer knowledge is necessary; specialized knowledge of radio systems is required to maintain the radio	520 (10 hrs / wk)	Unknown.	Primarily the state maintenance budget	Computers need rebooting on a regular basis; system is 15-20 years old and needs regular corrective maintenance
Weigh Station Networking	Desktop computer with internet capability	17	1995-96	Repair external components as necessary, repair networking equipment as necessary, upgrade of software when available	Annually clean the inside of the desktop	In-House	Vehicle Enforcement systems support person or Office of Information Technology		Networking, computer setup, software maintenance	Unknown	Unknown	Kentucky Transportation Cabinet	None specific

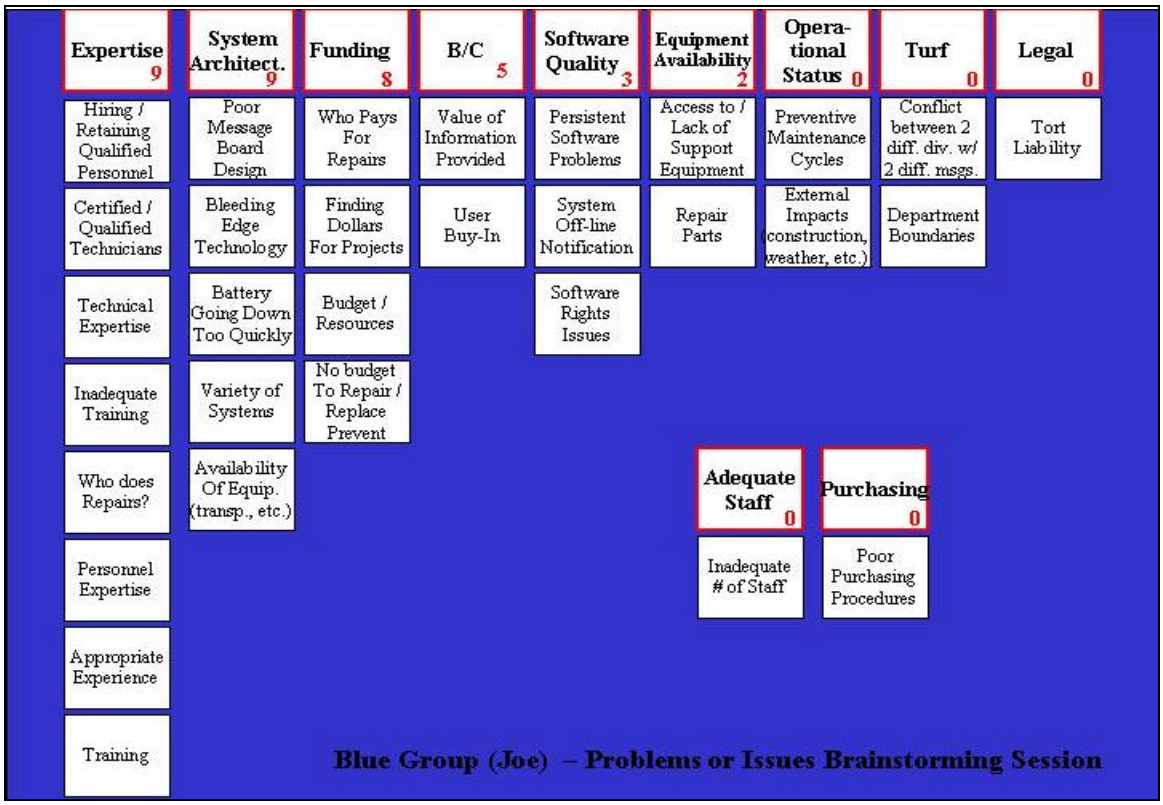
Project	Operations Activities	In-House, Contract, or Both	Specific Company or Agency doing Operations	Operations Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Operations	Funding	Operational Problems
Road Weather Information Systems	1. Verify that the system is running properly 2. Copy data to archive once per month.	In-House	ITS - Operations (Glenn Anderson)	N/A	Knowledge of Labview programming, computers, software, sensors, data communications, telephony, power distribution, electromechanical sensors, digital video cameras, microwave sensors, surge protection	416 (Ops & Maintenance)	$21,000	State - Operations	Very few - state office building network maintenance will sometimes interrupt operation
CVs - laptops / wireless communications	1. NCIC checks 2. Kentucky Observation file checks 3. Send ASPEN inspections over the system 4. Send in an evaluation form at the end of each shift.	Contract	SAIC		One day training received on the system; and one day to become NCIC certified	To be determined	To be determined	UCJIS and Federal Funds	Small bugs early; coverage issues have been resolved
AIRS	Change out VHS tape when it becomes full	Contract	Northrop Grumman		Knowledge of electronics and computers; vendor training was provided at the time of installation	60	<$15,000	State - Operations	None
ARTIMIS	1. Monitoring of cameras, radio frequencies, and two-way radios 2. Communication with dispatch, police, aircraft, service patrols 3. Collation of all data inputs 4. Preparation of incident reports 5. Dissemination of information via DMS, HAR, 511, website, pager alerts, and all media outlets 6. Receptionist, program oversight, incident liaison	Contract	Northrop Grumman		Training is required and is a minimum of 120 hours, including a written test if live recordings are made, a good speaking voice is essential	~30,500 (control room staffing only - does not include receptionist, system administrator, van drivers, or other project personnel)	$3.5 M for ODOT and KYTC	CMAQ (20%) National Highway System funds (60%), and FD 04 State matching funds (20%) - eventual migration to State Operations funds	None
Cumberland Gap Tunnel	Monitoring and control of the traffic, daily checks of the mechanical equipment, electrical equipment, emergency response vehicles and supplies, and all other vehicles; equipment is monitored and tested on a regular basis	Contract	CGTA personnel		Staff was trained as an obligation of the construction contractor; new personnel receive the necessary job training	Unknown	$251,500 (raw labor cost)	State - Operations (reimbursed 50% by Tennessee)	None
IRIS Van	System setup, operation during the day, system shutdown, and charging	In-House	Kentucky Vehicle Enforcement		2 to 3 days hands-on training with IRIS company	2000 to 3000	$1000 to $5000	MCSAP	None

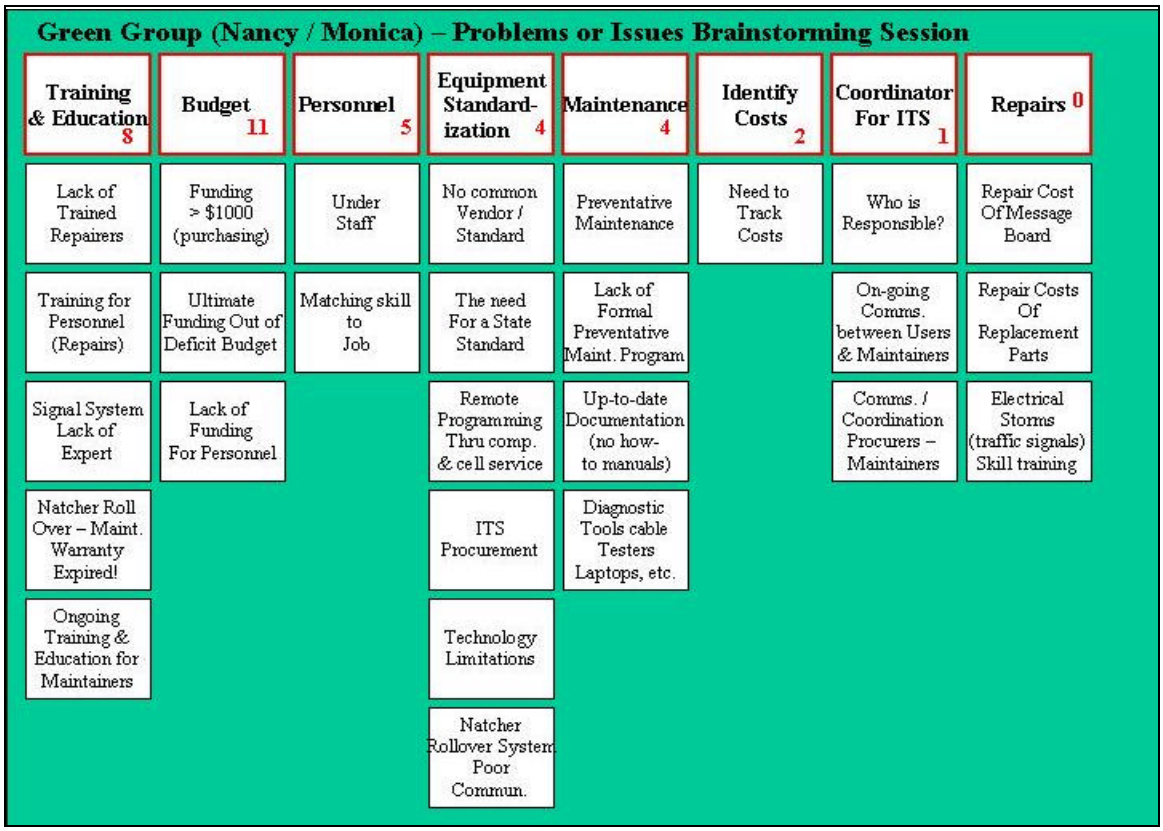
Project	Operations Activities	In-House, Contract, or Both	Specific Company or Agency doing Operations	Operations Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Operations	Funding	Operational Problems
NORPASS	Marketing to motor carriers, enrolling vehicles, and managing the enrollment database	Contract	Kentucky Transportation Center		Training in use of system software; familiarity with system enrollment requirements	Unknown	$150,000 (but amount reduces each year)	Department of Motor Vehicles, Division of Vehicle Enforcement - CVISN related	Lack of convenient access to credentials information for trucks that do not have Kentucky as their base state.
Rest Area Traveler Information	Same as maintenance	In-House	1. Rest area foreman 2. Division of Operations, Central Office, Gary Mitchell and Iona O'Banion	1. Inspection of the kiosks 2. Updating the information	1. None 2. Training in the software	500	Unknown	State maintenance budget	System is slow to update information due to satellite connection, requires using software that is old and not used for any other purpose now
Remote Monitoring System	Enforcement personnel periodically monitor the system and may need to intercept some vehicles	In-House	1. Weigh station personnel		General training on how to use the system	None, because this system is currently not being used.	None, because this system is currently not being used	Department of Vehicle Regulation operational funding	Nighttime operation is poor due to insufficient lighting; system also generates false triggers; staffing shortages make it difficult for anyone to spend time monitoring the system
TRIMARC	Daily monitoring of traffic conditions, control of field devices, coordination of freeway management with other transportation and public safety agencies, system management of a computer and communication resources, data collection and archiving, system enhancements, system expansion, scheduling activities for special events and off-hours maintenance actions	Contract	Northrop Grumman		Skill set includes: program management and fiscal control, systems engineering, computer systems administration, electrical engineering, software engineering, public communications protocol, ITS engineering, transportation planning, and civil engineering	12,480	~$1.5 million	Operations Funds	An extension of operational hours or further system enhancements are needed to provide 24/7 effectiveness
511	Monitoring 511 CARS Call Center activities and insuring smooth operations, and inputting the Road Condition Report (RCR)	Both	1. BeVocal 2. Statewide TOC executive director and other staff	1. Monitors 511 CARS activities and ensures smooth operations 2. Inputs Road Condition Report (RCR)	Knowledge of how to input RCR information into the 511 system	Unknown, hours vary	$213,000 for contract to BeVocal, unknown for in-house effort	FE 01 Office of Technology funds	System has crashed once due to failure of calls to "roll-over" to a pool of spare telephone circuits

Project	Operations Activities	In-House, Contract, or Both	Specific Company or Agency doing Operations	Operations Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Operations	Funding	Operational Problems
C.V. Electronic Credentialing	No information available for this report.								
IRP Clearinghouse	No information available for this report.								
Anti-Icing Bridge	This system is not being used.								
IFTA Clearinghouse	No information available for this report.								
Portable DMS	Checking the status of the message board and changing message, hauling sign to where it will be displayed	In-House	District personnel (the specific division varies depending on the district)		Very little; general computer knowledge	Varies	Varies	Varies	Poor software, battery capacity in low sunlight conditions, transporting the signs can lead to loose connections with wiring, not able to use remote access with signs - problem could be with laptop, modem, or software (possible solution - purchase ADDCO laptops which are built to use with signs
Signal Systems	Fielding calls / complaints, checking system coordination, checking radio units	In-House	In-House		Traffic signal system expertise, IMSA Signal Technician certification	Varies	Varies	FE 04 Traffic Budget	Some systems do not have remote communication capability, no technical support with Darcom system, sometimes loop detectors are paved over, video detection do not always work properly, incorrectly engineered signal systems and lack of follow-through and coordination with district and central office, one radio communication system never worked, two video detection systems never worked in area that had heavy fog,

Project	Operations Activities	In-House, Contract, or Both	Specific Company or Agency doing Operations	Operations Duties for the Specific Agency	Specialized Training	Average Staff Hours / Year	Annual Cost of Operations	Funding	Operational Problems
I-65 Bowling Green	Calling cameras, viewing images, composing messages and downloading to signs	In-House	Resident Engineer and Operations (district) - maybe TOC in the future		Ability to setup and use dial-up windows networking, browsers, ADDCO brick control software; ability to compose appropriate messages for display	Unknown	Unknown	Operations & Traffic Overhead	Currently the camera images must be manually retrieved by calling the site and viewing the image on a browser, only one person at a time can view the image and the process is cumbersome
Truck Rollover Warning System	Call up the system weekly to verify it's operation	In-house	District traffic engineer		Minimum specialized training is required for those who operate the system	4.5	Unknown	Traffic Budget	Frequent problems communicating with the system
TOC	Staff monitors the equipment and does work as needed	In-house	Office of Transportation Operations		Training as a dispatcher and training on the software in the Center	14 staff working on various shifts, 24 hours a day, 7 days a week	Unknown	State funds	Training
Weigh Station Networking	Resetting passwords, repair network problems	In-house	Vehicle Enforcement systems support person or Office of Information Technology		None	Unknown	Unknown	Kentucky Transportation Cabinet	None

Appendix C


Expertise 9
Hiring / Retaining Qualified Personnel
Certified / Qualified Technicians
Technical Expertise
Inadequate Training
Who does Repairs?
Personnel Expertise
Appropriate Experience
Training
System Architect. 9
Poor Message Board Design
Bleeding Edge Technology
Battery Going Down Too Quickly
Variety of Systems
Availability Of Equip. (transp., etc.)
Funding 8
Who Pays For Repairs
Finding Dollars For Projects
Budget / Resources
No budget To Repair / Replace Prevent
B/C 5
Value of Information Provided
User Buy-In
Software Quality 3
Persistent Software Problems
System Off-line Notification
Software Rights Issues
Equipment Availability 2
Access to / Lack of Support Equipment
Repair Parts
Opera-tional Status 0
Preventive Maintenance Cycles
External Impacts construction, weather, etc.)
Turf 0
Conflict between 2 diff. div. w/ 2 diff. msgs.
Department Boundaries
Legal 0
Tort Liability
Adequate Staff 0
Inadequate # of Staff
Purchasing 0
Poor Purchasing Procedures
Blue Group (Joe) – Problems or Issues Brainstorming Session


Green Group (Nancy / Monica) – Problems or Issues Brainstorming Session
Training & Education 8
Lack of Trained Repairers
Training for Personnel (Repairs)
Signal System Lack of Expert
Natcher Roll Over – Maint. Warranty Expired!
Ongoing Training & Education for Maintainers
Budget 11
Funding > $1000 (purchasing)
Ultimate Funding Out of Deficit Budget
Lack of Funding For Personnel
Personnel 5
Under Staff
Matching skill to Job
Equipment Standard-ization 4
No common Vendor / Standard
The need For a State Standard
Remote Programming Thru comp. & cell service
ITS Procurement
Technology Limitations
Natcher Rollover System Poor Commun.
Maintenance 4
Preventative Maintenance
Lack of Formal Preventative Maint. Program
Up-to-date Documentation (no how-to manuals)
Diagnostic Tools cable Testers Laptops, etc.
Identify Costs 2
Need to Track Costs
Coordinator For ITS 1
Who is Responsible?
On-going Comms. between Users & Maintainers
Comms. / Coordination Procurers – Maintainers
Repairs 0
Repair Cost Of Message Board
Repair Costs Of Replacement Parts
Electrical Storms (traffic signals) Skill training

Yellow Group (Jennifer) – Problems or Issues Brainstorming Session

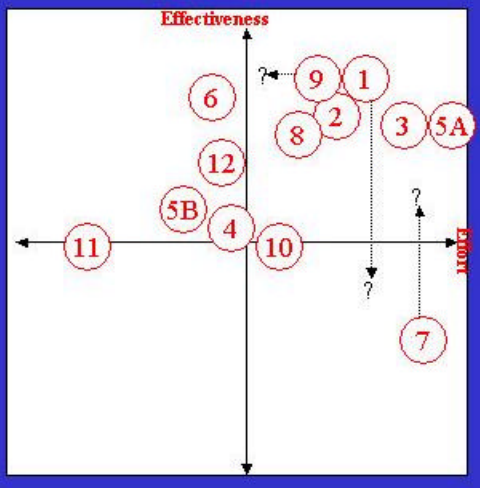
Lack of Training 7	Under Utilized Systems 5	Maintenance Respons. Who has it & how? 5	Excessive Maintenance Required 3	Difficulty Obtaining Parts 3	Lack of Policy Enforcement 5	Lack of Program Development 4	Need for Test Equipment 2
Training	RWIS Units Being Used?	Central or District Maintenance	CVM Stations Camera Problems	Local Inventory of Parts	Portable Message Boards – Proper Use	Not Enough 511 Lines for Large Incidents	Array of Test Equipment Required
Technical Support from Vendors	RWIS Video?	Repair vs. Replace Decisions	CVM Stations Scale Maintenance	VMB: Parts / Inventory Suppliers Price Contract	VMB: Mess. Text, Proper, Effective, Guidelines	Signal Timing Not Updated	System "Heartbeat" Available
Specialized Training for Repair & Maintenance	Viewing of Other States RWIS Info	Overall Maintenance Contract	Sensitivity & Fog Out Problems (camera)	Different Manufacturers & Technologies	511 (CARS) Who enters What, When, and How?		
	ARTIMIS & TRIMARC Benefits for KyTC	VMS's Need Maintenance Contract	Vandalism of Variable Message Boards	Software Problems (camera)			
			Weather Induced Maintenance Activities				

Lack of 2 Preventative Maintenance	Need for Central 0 Maint. DB
Anti-Icing Bridge Call-up System	Configuration Management H/W & S/W
	Upgrades / Updates Full vs. Phased
	Ability to Accurately Capture Costs

Blue Group (Joe) – Solutions Brainstorming Session (page 1)

Issue: Funding

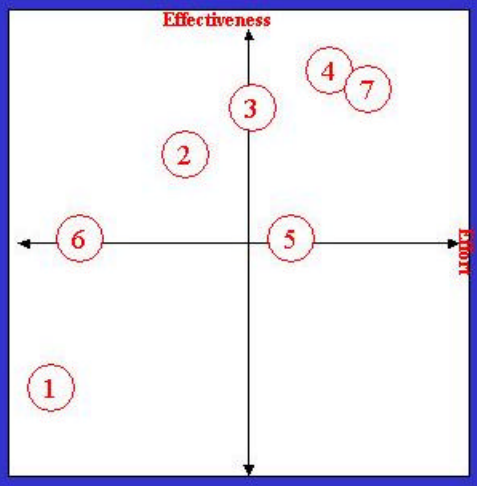
1. Increase gas tax
2. Allocation (make case to decision-makers for ITS dedicated funding)
3. Toll Roads with ITS
4. Grants to free up money for O&M
5. Privatization
   - 5A – Roadway
   - 5B – O&M
6. Prepare projects with O&M, life-cycle costs
7. Advertising / naming rights
8. Increase traffic budget to include O&M
9. Charge utilities for use of ROW
10. Bonds
11. Public support campaigns
12. Lobbying in Washington



Blue Group (Joe) – Solutions Brainstorming Session (page 2)

Issue: B/C or Under Utilized Systems

1. Get rid of them
2. Outreach to users
3. Outreach to decision makers/managers
4. User-friendly h/w and s/w
5. Do B/C analysis of systems
6. User surveys
7. Provide timely / accurate info



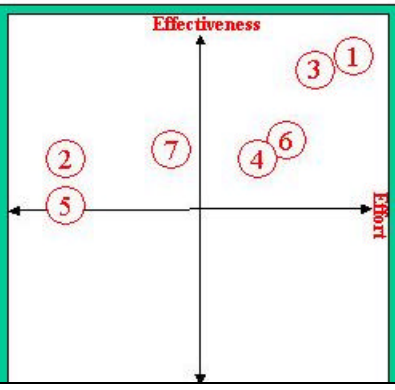
Green Group (Nancy / Monica) – Solutions Brainstorming Session (page 1)

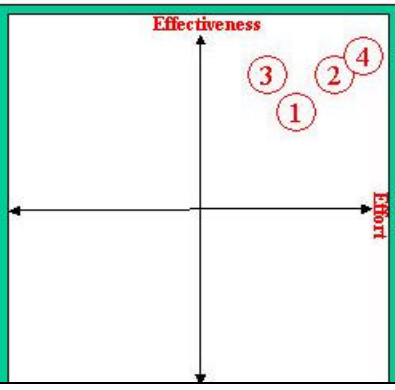
Issue: Personnel

1. More $
2. Identify trained personnel needs / consequences of not having the personnel
3. Cap issues – raise / remove – limited # of personnel
4. Updated job classifications
5. Cross-training
6. Career ladder potential
7. Outside training (e.g. vendors)
8. Need to create new branch for traffic signal system implementation & retiming (***added later***)

Issue: Equipment Standardization

1. Precise specs.
2. Interoperability
3. Local tech. Support
4. Responsive procurement procedures / system (flexible)



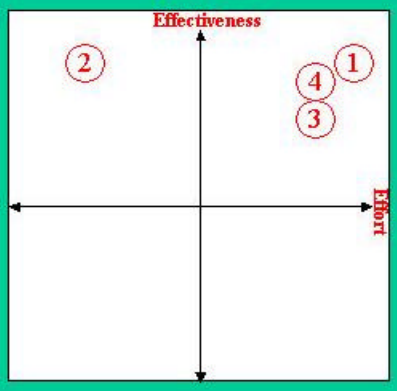


Green Group (Nancy / Monica) – Solutions Brainstorming Session (page 2)

Issue: Maintenance

1. Identify preventive maintenance requirements for tech.
2. Schedule maintenance
3. Support Schedule
4. Have preventive maintenance items on-hand

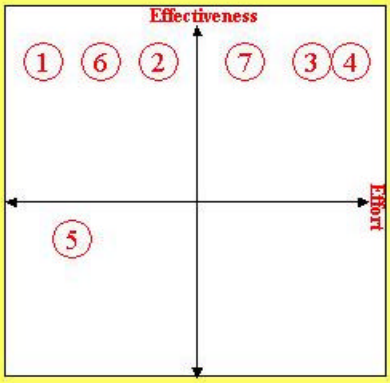
Prioritize / manage



Yellow Group (Jennifer) – Solutions Brainstorming Session

Issue: Lack of Training

1. Identify training needs
2. Inventory of systems we have
3. Develop a program manual
   - •Training requirements
   - •Purpose of system
4. Develop an operational manual
5. Management emphasis on training
6. Mandate in contract that vendor must provide on-going training
7. Job-specific training / hands-on



Issue: Who has maintenance responsibilities and how is it performed?

1. Identify maintenance needs
2. Develop a maintenance strategy
   - Level of maintenance: in-house (specifically who) vs. out-sourced
3. Repair vs. replace decision making
4. Define system owner