Chapter 9

Intelligent Transportation Systems

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INTELLIGENT TRANSPORTATION SYSTEMS

One of the most promising solutions for mitigating congestion and improving safety in metropolitan areas, as well as addressing some other major transportation issues, is an Intelligent Transportation System (ITS). In an ITS, advanced communication technologies are linked to the transportation infrastructure so that it can move more people and goods and move them more quickly. Intelligent transportation systems represent the application of information processing, communications technologies, advanced control strategies, and electronics to the field of transportation.

NATIONAL ITS ARCHITECTURE

The Transportation Equity Act for the Twenty-First Century (TEA-21) requires ITS projects funded through the highway trust fund to conform to the National ITS Architecture, applicable or provisional standards or protocols. The proposed implementing regulations for this provision of law have been introduced. The regulations require conformance to the proposed national standards but encourage each metropolitan area to develop their own systems within the national framework that will support their future transportation needs. ITS projects require a high level of coordination between many agencies and work best when the entire systems are integrated. OKI recognizes this and has taken a lead in this area by forming the ITS Advisory Committee. The Committee is developing a regional ITS plan that will define standards and establish recommendations for ITS projects in the OKI region. That plan will be completed in 2001 and its recommendations will be incorporated into the next update of the metropolitan transportation plan.

ITS Components

An ITS is comprised of one or more technology systems depending on a metropolitan area's needs. Initially, the ITS core components focused on the freeway system, but technology systems are also being applied to major arterials and intersections, transit systems, and intermodal connections. In an integrated ITS, multiple components support each other and optimize the transportation system's efficiency. Among the most common core components are those listed below:

- An **Advanced Traffic Management System**, usually focused on freeways, collects information on traffic conditions and transmits the data to a control center for use in monitoring traffic conditions and detecting congestion problems.

- A **Traveler Information System** provides information to help motorists avoid congestion. This information, which may be obtained prior to or during travel, can include real-time traffic conditions, routing alternatives, transit schedules, assistance with rideshare registration, and other travel-related information.

- An **Incident Management Program** detects, verifies, and transmits information on the location and nature of vehicle accidents or breakdowns so that the appropriate emergency service can be quickly dispatched, thereby reducing incident response and removal times.

- An **Advanced Traffic Monitoring System** provides a repository for data used in transportation planning and transportation system management.

- An **Advanced Public Transit Management System** enables bus fleets to be operated so that travel time is reduced and customer service and security are enhanced.

- A **Traffic Signal Control System** synchronizes the timing of multiple traffic signals in a corridor in order to improve traffic flow and reduce stop-and-go travel.

- **Electronic Fare Payment Systems** for parking, bus and train fares as well as tolls.

In 1996, the U.S. Department of Transportation launched a new initiative to promote the application of intelligent transportation infrastructure. The expressed intent of this initiative is to reduce average travel time in the nation's major metropolitan areas by at least 15 percent in the next ten years.

In reducing travel time, an ITS' effectiveness is the combined result of its core components. These technologies contribute individually and through interaction with each other to reduce congestion and delay, increase travel speeds and traffic throughput, reduce the frequency and severity of accidents, and optimize the existing transportation system. By moving more traffic more quickly, an ITS can eliminate the need for new transportation facilities. An ITS can also be significant for improving safety and lowering vehicle emissions and fuel consumption.

The ITS has been touted as the next step in the evolution of the nation's entire transportation system. From numerous studies on the benefits of ITS deployment in various cities, it is evident that benefits are consistently positive but vary greatly based on differences in technologies and traffic conditions. The potential for ITS benefits to counter highway capacity expansion, however, is indicated by a six-year study of Seattle's ramp metering and freeway management system showing that speeds remained steady or increased up to 20 percent at the same time that traffic volumes grew 10 to 100 percent.[1] The U.S. Department of Transportation estimates that it costs less to build a complete set of core ITS infrastructure, for the benefit of travel throughout a metropolitan area, than to build ten miles of urban freeway for the benefit of only a single travel corridor.[2]

ARTIMIS

The OKI region's ITS is called ARTIMIS, the Advanced Regional Traffic Interactive Management and Information System. ARTIMIS evolved from OKI's interest in reducing congestion from interstate reconstruction, which was scheduled to begin in 1987 and last for several years, and in ITS potential to optimize freeway system efficiency, improve safety, and benefit air quality. ARTIMIS was initiated by OKI's completing a feasibility study in 1988, followed by a preliminary engineering design in 1991. Through the teamwork of OKI, the Kentucky Transportation Cabinet (KYTC), the Ohio Department of Transportation (ODOT), and local governments, ARTIMIS was designed to provide consolidated traffic management without regard to state and local political boundaries. Today, ARTIMIS serves 51 separate jurisdictions in Ohio and 20 in Northern Kentucky.

When it came fully on line in early 1998, ARTIMIS became one of the first ITS in the country to provide seamless freeway traffic management across state borders. ARTIMIS covers the 88 miles of the region's freeway system with the heaviest traffic:

- I-75, I-71 (including Fort Washington Way), and I-471 within the I-275 beltway
- The I-75/I-71 segment south of the beltway to US 42
- I-275 in northern Hamilton County between US 22 (Montgomery Road) and SR 4
- I-275 in northern Kentucky from Kellogg Avenue and the Ohio River Bridge to the Cincinnati/Northern Kentucky International Airport
- Ronald Reagan Highway between I-75 and I-71
- SR 562 (the Norwood Lateral)

ARTIMIS is operated by traffic controllers stationed at a control center. The control center, sited in downtown Cincinnati and centrally located on the ARTIMIS system, receives all of the information collected from the field. The control center is the point from which traveler information is disseminated and traffic is managed.

ARTIMIS' components are listed below.

The **Advanced Traffic Management System (ATMS)** collects information on traffic conditions per lane and transmits it to the control center. The information is collected by loop detectors installed in the pavement every third to half mile, wide beam radar detectors on I-71, and video cameras on Fort Washington Way. These technologies collect traffic speed, volume, and vehicle density data throughout the entire ARTIMIS system, in addition to providing visual surveillance on some segments for use in verifying congestion and determining the cause of incidents. When traffic speeds drop below a certain level, controllers are alerted to conditions that may warrant remedial action. On I-75 and parts of I-275 — which are the most heavily traveled freeways — closed circuit television (CCTV) cameras provide pan-tilt-zoom capabilities for full-motion video coverage that make these segments completely visible at the control center.

The **Advanced Traveler Information System (ATIS)** is one of the most sophisticated traveler information components in the country. It provides information on traffic problems and alternative routes through a combination of changeable message signs strategically located throughout the system, a highway advisory radio frequency, and a multi-faceted traveler advisory telephone service. The telephone service makes information available through either a touch-tone or cellular phone and can be accessed anywhere in the region by dialing "511". "511" replaces the original "211" and will be the national standard for traveler information systems. Motorists nationwide can access the local traveler information service by calling "511." The OKI region is the first area in the United States to make the changeover. The service provides such travel-related information as:

- Up-to-the-minute and route-specific traffic conditions
- Bus routes and schedules of the region's two largest transit operators (Metro and TANK)
- Airport shuttle service and schedules
- OKI's rideshare matching program and registration process
- Interstate reconstruction, for which information is disseminated through the "Beat the Jam" program, not only through the telephone service but also via the media and printed materials

Since its inception in 1996, the "211" system has handled over four million calls, and its use has steadily increased.

To supplement information on traffic conditions, approximately 200 mobile "probes" — which include buses, OKI rideshare vans, and cell phone users — and spotter aircraft report information observed while traveling or from flights made during peak hours.

The **Incident Management Program** expedites the relay of information on incident occurrence, cause, and location to those involved in emergency response, such as 911 dispatchers, police and fire departments, paramedics, towing services, and emergency management services. To further expedite incident response and removal, this program includes the following special features.

- The **Freeway Emergency Service Patrol**, which operates three vans in Ohio and two in Kentucky on assigned freeway segments, provides gas, minor repairs, or other assistance to disabled vehicles to expedite their returning to operation or moving onto the shoulder or off the freeway.
- **Median markers** are located every tenth of a mile for use in accurately reporting and quickly locating incident locations. These specially-designed markers, and also signs located on each ramp that identify direction and location, are being used for expediting incident response time.
- A **Regional Incident Management Task Force** has been established to improve coordination among the many agencies involved in incident management. Task force members include representatives from fire and rescue; state and local law enforcement; emergency management and response organizations; communication centers; private towing services; local, regional, and state transportation agencies; and the American Red Cross. The Task Force mission is to set up regional policies and protocols for responding to incidents within a multi-state, "home-rule" setting, such as how to expedite the removal of abandoned vehicles.
- The **Traffic Monitoring System (TMS)** provides data for use in measuring the freeway system's performance. Data on travel speed, volume, and vehicle density by lane mile that is collected and stored from ARTIMIS' 1100 vehicle detection devices is supplemented by similar data and vehicle classification data collected by 22 double inductive loops strategically located throughout the region. This newly available detailed traffic data will support OKI's responsibilities for congestion performance monitoring under the Mobility Management Program (see Chapter 6). In addition, the data is valuable for transportation planning activities by OKI, local governments, ODOT, and KYTC.

RECOMMENDATIONS FOR EXPANDING ITS INFRASTRUCTURE

As freeway traffic continues to increase, ITS infrastructure will become increasingly important for reducing congestion and delay and otherwise improving traffic flow. To address this region's traffic problems, additional ITS infrastructure is recommended for ARTIMIS, bus fleets, freeway ramps, and traffic signal coordination.

As the region's ITS evolves, its performance will be determined not only by the deployment of new technologies but also by how well the technologies are integrated into the existing ITS. The addition of the recommended technologies, for example, will involve multiple jurisdictions and the private sector. As ITS technologies are deployed, public agencies and officials and the private sector must work with each other toward a shared vision. To optimize its potential, ITS expansion must occur within a framework that provides for interconnectivity and the free flow of information.

Recommendations for ARTIMIS

It is recommended that the existing ARTIMIS system be provided with full instrumentation along an additional 44 miles of freeway, as indicated in Figure 9-1.

Full instrumentation would involve extending fiber optic cable, adding closed circuit television (CCTV) cameras, and installing more detection equipment. The benefits of full instrumentation are related to better traffic control and faster response. Prior to deployment, consideration should be given to joint public-private use of fiber optics as a means of reducing costs to the public.

It is recommended that ARTIMIS be extended to cover an additional 119 miles of the region's freeway system, as indicated in Figure 9-1, inclusive of fiber optic cable.

The freeway segments to be included in the ARTIMIS extension are:

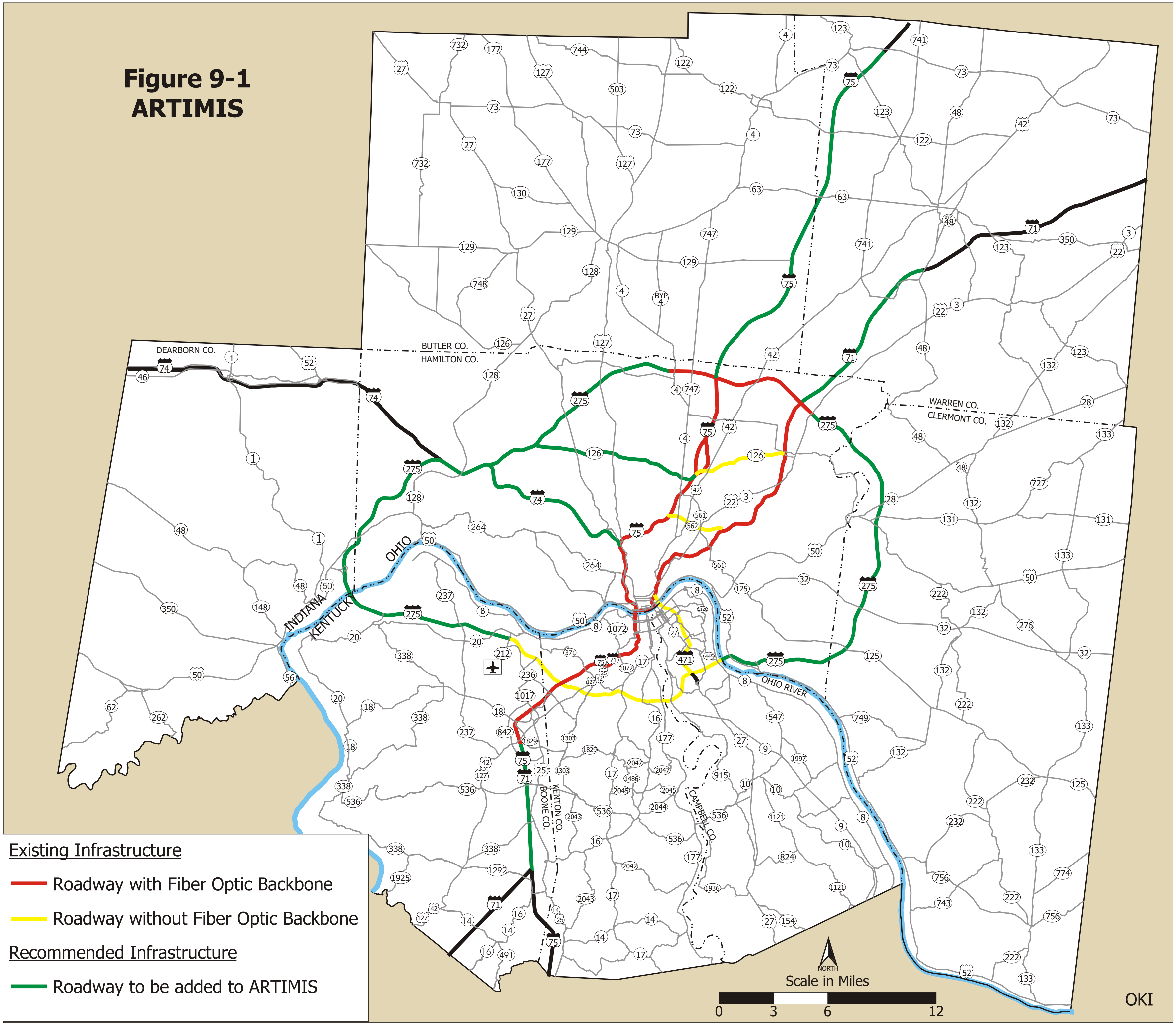
- the remainder of I-275
- I-74 inside the beltway
- I-75 outside the beltway north to SR 73
- I-71 outside the beltway north to SR 48
- I-75/I-71 outside the beltway south to the junction where I-75 and I-71 separate
- Ronald Reagan Highway between I-75 and I-275

It is recommended that a pavement temperature monitoring system be installed on the region's most heavily traveled bridges and freeway segments to provide road maintenance agencies and travelers with information on icy conditions.

In this system, in-pavement sensors would measure and transmit data on road surface temperatures and atmospheric conditions to the traffic control center or other locations. The information would be used to alert travelers to route-specific conditions and help road maintenance agencies with scheduling de-icing operations.

It is recommended that ITS technologies be applied at high-risk rail-highway grade crossings to improve safety.

Figure 9-1
ARTIMIS



These technologies would transmit data at high-risk intersections to the control center for use in alerting drivers and optimizing traffic flow. This application's potential benefit is suggested by the region's having more than 600 railroad crossings. Study is needed to identify the rail-highway grade crossings for which ITS technologies would be most appropriate and to identify the most appropriate technologies for each intersection.

It is recommended that traveler information kiosks be provided at the Cincinnati/Northern Kentucky International Airport to provide traffic information at the terminal and car rental locations.

Kiosks would provide travelers with ARTIMIS information such as freeway traffic conditions, the cost and location of parking facilities, and information on car rentals, taxi and limousine service, and bus transit.

Recommendations for Transit ITS Infrastructure

Metro is outfitting its bus fleet with ITS technology. The ITS infrastructure includes a ten channel 800 MHZ state-of-the-art system, Automatic Vehicle Locator (AVL) equipment on 455 buses and paratransit and support vehicles, and Computer Aided Dispatch (CAD) controls for buses and paratransit vehicles. The AVL and CAD system combination uses satellites and computers for tracking vehicle real-time locations in order to provide a variety of capabilities for improving security and fleet management.

It is recommended that ITS technologies be installed for better managing TANK's bus fleet.

Metro has reserved channels on the 800 MHZ radio system in anticipation of future ITS installation at TANK. Once TANK completes the installation, real-time data and information can be shared between the two transit systems. Recently, a transit only radio channel of communication was established between TANK, Metro and ARTIMIS. Ideally, Metro and TANK dispatch operations should be located in the ARTIMIS control center to facilitate their sharing real-time data and information, but Metro has opted to locate its dispatch operations in its own facility. As ARTIMIS is expanded and integrated with traffic signal systems on arterial roadways, the benefits of coordinating transit and ARTIMIS will become more pronounced.

Recommendations for Ramp Metering

Ramp meters are traffic signals installed on freeway entrance ramps to regulate traffic's merging into mainstream flow. By controlling the number and timing of vehicles entering the freeway, the ramp meters help to improve freeway speeds, reduce side-swipe and rear-end incidents, and reduce non-recurring congestion from accidents. Surveys of ramp metering systems have reported throughput increases of 8 to 22 percent.[3]

There are many variations of ramp metering. The systems range from a fixed time operation at a single ramp to computerized control of every ramp along many miles of freeway. They can be operated to allow vehicles to merge one or two at a time and prevent mainstream breakdowns. In addition to facilitating merging, ramp meters can also be used to control traffic volumes so that downstream capacity is not exceeded.

It is recommended that the feasibility of ramp metering on heavily traveled freeway segments be studied as part of future corridor studies.

There are 77 on-ramps on the freeway covered by the existing or proposed ARTIMIS. The ramps most appropriate for metering would be those where traffic merges into the highest traffic volumes.

Recommendations for Traffic Signal Synchronization

In addition to its application on freeways, ITS infrastructure also has the potential to reduce congestion on arterials. Much of this off-freeway congestion occurs in suburban areas where new development is taking place. In these areas, ITS technologies can be used to better synchronize traffic signals through relatively low cost management systems. In Abilene, Texas, for example, a closed-loop signal control system reduced delays up to 37 percent and increased travel speeds as much as 22 percent.[4]

It is recommended that local governments consider traffic signal synchronization on major arterials when replacing existing signal systems. Local governments should work cooperatively to overcome jurisdictional issues.

Ideal locations for traffic signal coordination are those areas where extensive commercial and outlying residential development have spurred significant congestion, causing traffic to move slowly on miles of arterials and to move slowly onto freeway ramps. Often, the division of responsibility among multiple jurisdictions complicates technical issues. Intergovernmental coordination is needed to standardize, build, and operate an integrated signal system that improves mobility across jurisdictional lines.

Specific issues needing coordination include:

- Hardware and software compatibility
- The potential for inter-connecting traffic signal systems or making other enhancements
- The installation of fiber optic cable and other ITS technologies
- The potential for joint use of fiber optic cable by the public and private sectors
- The potential for inter-tying signal systems with ARTIMIS
- The need for a local traffic control center(s)
- The need for a coordinated multi-jurisdictional operation and maintenance function

Fiber optic cable is being used increasingly for traffic management, as well as other applications in both the public and private sectors.

Before using public right-of-way for fiber optic cable, it is recommended that local governments coordinate with potential users to determine the conduit and type and number of fibers needed and to explore options for private funding participation.

The fiber optics cable used for transportation technologies has other potential applications for telecommunications. Because these applications affect conduit and cable requirements, potential users of fiber optics in public rights-of-way — in both the public and private sectors, including neighboring communities — should be surveyed. The survey should identify existing and future fiber optic needs, including the type and quantity of data, for use in determining the type and number of fibers needed. For any local government, such a survey should precede the purchase or installation of conduit or cable in order to protect and maximize the benefits from public investment.

Studies and Costs for Implementing Recommendations

For each of the preceding recommendations for ITS infrastructure, studies are needed to address such issues as specific infrastructure needs, phasing, deployment procedures, and cost estimates. Table 9-1 provides cost estimates for the studies and, in some cases, for infrastructure expansion.

The annual operating and maintenance cost of ARTIMIS is estimated at $5.4 million.

Table 9-1
Cost Estimates for ITS Infrastructure Expansion

Recommendation	**Study**	**Deployment**
Strategic ITS Planning	$650,000	
Full instrumentation of existing ARTIMIS		$7,500,000
Extension of ARTIMIS coverage		$40,500,000
Pavement temperature monitoring system		To be determined
Rail/highway grade crossing safety study		To be determined
Airport information kiosk		To be determined
Transit ITS infrastructure		$4,000,000
Ramp metering system	$275,000	To be determined
Traffic signal synchronization	$650,000	To be determined
Total	$1,575,000	$52,000,000

REFERENCES

[1] U.S. Department of Transportation, Federal Highway Administration, sponsor. *Review of ITS Benefits: Emerging Successes*. Prepared by Mitretek Systems. Washington, DC.: September, 1996, p.8.

[2] Christine Johnson. "Accelerating ITS Deployment: A Report from the U.S. DOT," *ITE Journal*. December, 1995, p.66.

[3] Michael F. McGurrin and Dwight E. Shank. *Meeting the Growth in Travel: The Role of ITS*, p.6.

[4] U.S. Department of Transportation. Operation TimeSaver. *Intelligent Transportation Infrastructure Benefits: Expected and Experienced*. January, 1996, p.5.