Final Draft

October 1995

Task 8 - Technical Memorandum

Strategic Deployment Plan

ITS Strategic Plan

The Early Deployment of Intelligent Transportation Systems (ITS) In Maricopa County

Maricopa County Department of Transportation

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Steering Committee Agencies

AAA
ADOT
ASU
Chandler
DPS
Federal Express
FHWA
Glendale
MAG
Maricopa County
Mesa
Motorola
PAG
Peoria
Phoenix
RPTA
Scottsdale
Sky Harbor
SRPM Indian Comm
Swift Transportation
Tempe
UPS

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SECTION I - BACKGROUND AND INTRODUCTION

1.1 Project background

Maricopa County ITS Strategic Plan is an effort undertaken by the Maricopa County Department of Transportation and a coalition of private and public agencies to develop a plan for deploying ITS technologies. The vision for this project is to identify innovative ITS technologies for deployment in Maricopa County to satisfy regional transportation needs.

The Federal Highway Administration (FHWA) has developed a Planning Process, depicted in **Figure 1.1-0,** to aid local/regional agencies in the development of ITS Strategic Plans. In addition, a National Program Plan for ITS has been prepared to provide a general framework to guide ITS investment decisions and promote ITS goals.

Maricopa County has outlined a process, the Maricopa County Early Deployment Strategic Plan, which closely parallels the National ITS Program Plan and FHWA Planning Process. The Early Deployment Plan consists of eight sequential tasks, described below. This project fulfills the requirements of the Early Deployment Strategic Plan.

1.1.1 Maricopa County ITS Strategic Plan Tasks

Task 1: Examine the existing coalition/institutional framework for expansion and modification. Develop a vision statement and a mission statement with the coalition. Identify regional transportation needs and deficiencies with respect to safety and mobility.

Task 2: Establish short-, medium- and long-range time frames. Based on the varying perspectives of the coalition members, list the short-, medium- and long-range needs of the present transportation system. Match local transportation needs with the associated ITS user services and develop the specific objectives necessary to achieve the user service goals.

Task 3 : Develop a user service plan based upon the needs, goals. and objectives identified in Tasks 1 and 2. Identify and prioritize user services for short-, medium-, and long-range implementation.

Task 4: Establish performance criteria and system measures that can be utilized as a standard to determine how successfully the plan will meet the user service needs, goals, and objectives.

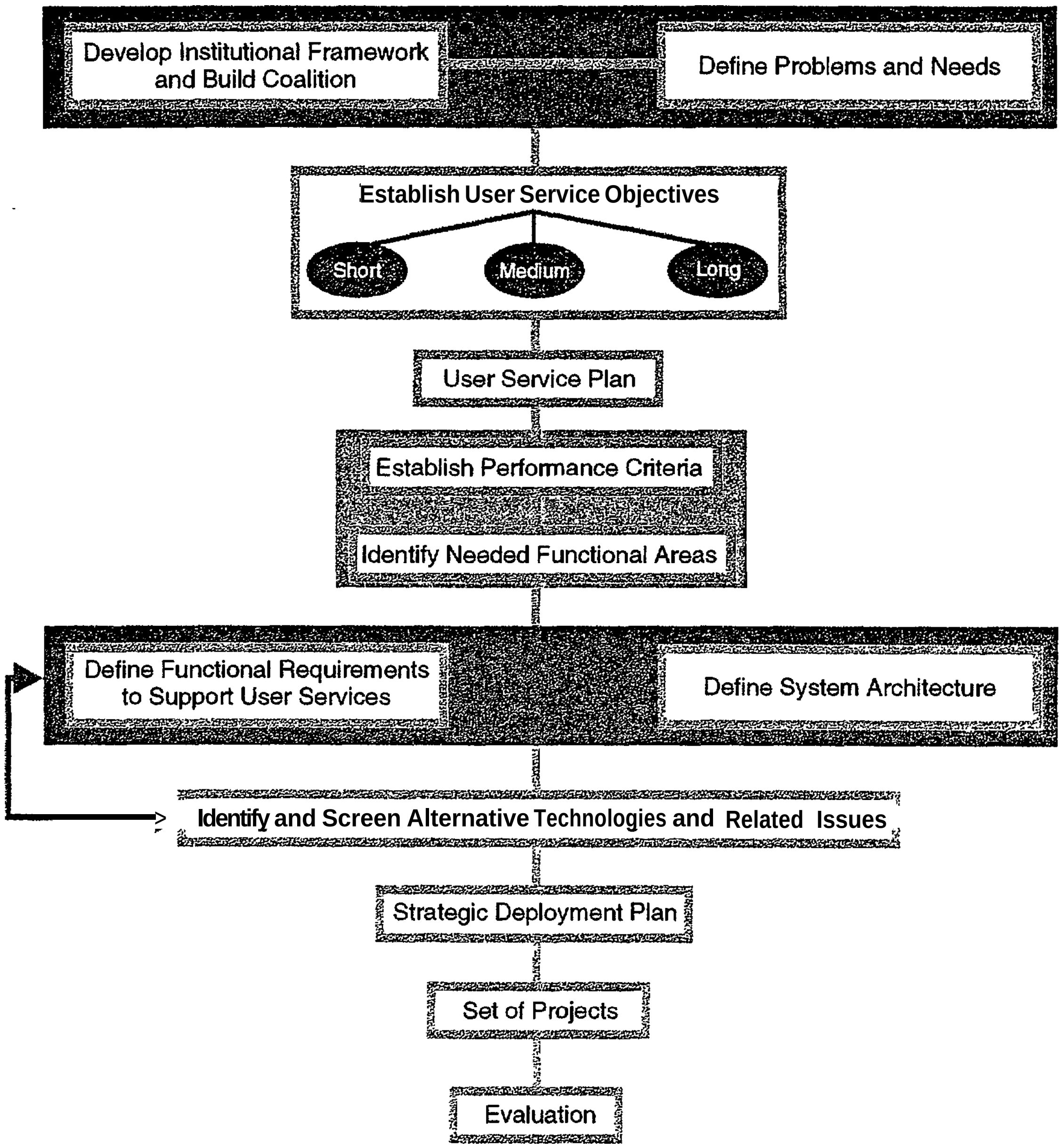
Task 5: Identify which combination of the FHWA's seven basic functional areas would best support the local user services. These seven functional areas include:

- Surveillance
- Traveler interfaces
- Navigational guidance
- Data Processing
- Communications
- Control Strategies
- In-vehicle sensors

Task 6: Based upon the functional requirements of the system, define the best system architecture.

Figure 1.0-l

ITS Planning Process



Task 7: Identify and evaluate alternative technologies on the basis of performance, reliability, costs, benefits, maintenance and operation requirements, and environmental impacts.

Task 8: Develop a region-wide Strategic Plan that meets the needs, goals, objectives, and standards established in earlier tasks. The plan will include a set of projects for short-, medium-, and long-range implementation.

The project scope of work includes the following six basic goals:

- Identify and document applicable ITS user services;
- Establish system performance criteria;
- Assess the functions and requirements of the system;
- Identify and evaluate potential technologies based on performance, compatibility, flexibility, and cost;
- Assess potential funding and implementation options; and
- Identify time frames for implementation.

1.2 Transportation Needs in Maricopa County

Initial project efforts of the Maricopa County Early Deployment Strategic Plan focused on identifying the problems, needs, and deficiencies of the present transportation system in the County. To assist in identifying these problems and needs, a Steering Committee and numerous focus groups were formed.

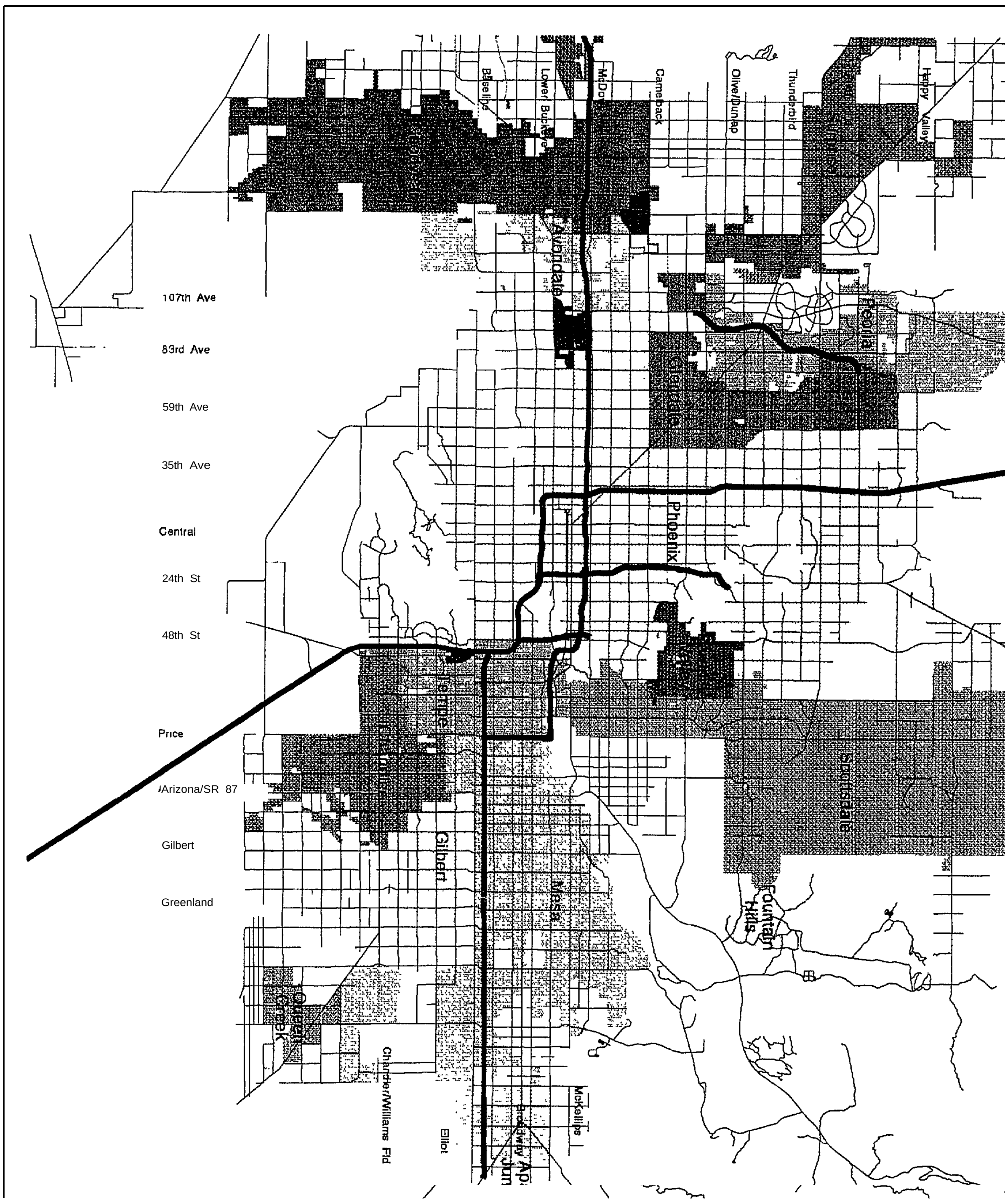
The Steering Committee, comprised of 24 representatives from the public and private sectors, includes state, county, and local agency representation, as well as key appointees from the transportation, education, delivery, and high-tech industries throughout Maricopa County. The Steering Committee has met monthly throughout the project to coordinate and direct the development of the ITS Strategic Plan.

The Steering Committee developed mission and vision statements for the Strategic Plan, which provided focus to the goals and objectives of this 12-month study.

Vision: To deploy innovative ITS technologies in Maricopa County to satisfy regional transportation needs.

Mission: To interact with transportation users in order to identify community needs and objectives, and apply the appropriate technology consistent with the National ITS Program to solve the area's transportation problems.

Focus groups **were** formed to assist the Steering Committee in gathering valuable insight from a diverse group of transportation system users throughout the County and promote greater public awareness, education, and involvement in ITS. These groups included representatives from emergency response/rescue teams, air travel and airport-related services, busing/transit, academic institutions, major employers, tourism/resort industry, and special events facilities. In addition, several municipal transportation advisory committees were solicited for information regarding transportation network problems and needs. Surveys similar to those received by the focus groups were also distributed to several members of the general public in an effort to ensure a diverse range of identified transportation needs. These surveys were used later as a tool to initially prioritize the goals of the Strategic Plan.



107th Ave
83rd Ave
59th Ave
35th Ave
Central
24th St
48th St
Price
Arizona/SR 87
Gilbert
Greenland
Baseline
Lower Buckeye
Camelback
Olive/Dunlap
Thunderbird
Happy Valley
Avondale
Peoria
Glendale
Phoenix
Tempe
Gilbert
Mesa
Scottsdale
Fountain Hills
Queen Creek
Chandler/Williams Fld
Elliot
McKellips

With the needs identified, the next step focused on the establishment of deployment time frames and an evaluation of the identified needs. The major emphasis of the needs evaluation was to determine the correlation between the needs and the FHWA defined User Services and the goals of the National ITS Program Plan. Additionally, the region's transportation program was reviewed to assure that a linkage was established between the goals and objectives of both the Maricopa County ITS Strategic Plan and MAG's Long Range Transportation Plan.

The establishment of the deployment time frames was made based upon three major considerations:

- The reauthorization of ISTEA (1997)
- Current plans for ITS and ITS projects in Maricopa County (i.e., FMS, MAGIC Projects, signal system upgrades, etc.).
- The typical five year planning horizon under which most agencies operate.

As a result, the Steering Committee established the following ITS deployment schedules:

- Short Term 1995 - 1999
- Medium Term **2000 - 2005**
- Long Term 2006andbeyond

1.2.1 User Services for Maricopa County

Each of the identified needs were matched, where possible, to one or more of the 29 FHWA User Services defined in the National ITS Program Plan. As a result of this evaluation and the development of objectives, the FHWA User Service bundles and User Services presented in **Table 1.2.1-1** were found to best represent the focus of early deployment ITS initiatives in Maricopa County.

TABLE 1.2.1-1
USER SERVICES AND USER SERVICE BUNDLES
BASED ON THE NEEDS OF MARICOPA COUNTY

User Service Bundle	**User Services Emphasized Based on Maricopa County's Needs, Systems & Problems**
Public Transportation Operations	• Public Transportation Management • Personalized Public Transit
Traveler and Transportation Management	• Traffic Signal Systems • Pre-Trip Traveler Information • En-Route Driver Information • Route Guidance • Traveler Services Information • Incident Management

The needs which resulted in these User Services were also matched to one or more of five national ITS goals, described in **Table 1.2.1-2.** These goals represent an improvement in safety, efficiency, the environment, productivity and mobility. Based on this comparison, it was determined that an improvement in both the efficiency and the mobility of the County's transportation network were the most important considerations of significant transportation network users; users want ITS to improve the level-of-service, security, and the accessibility of the transportation system by reducing congestion and the current level of traveler stress.

TABLE 1.2.1-2
ITS GOALS AND OBJECTIVES

Improve Safety	Reduce the number of motor vehicle collisions, and associated injuries and fatalities. Improve the response time of emergency medical services Improve the ability to handle HAZMAT incidents Enhance traveler security and roadway service responsiveness.
Increase Efficiency	Increase efficiency by smoothing flows Increase average vehicle occupancy Increase capacity of existing facilities Reduce vehicle miles traveled Reduce time lost in intermodal interchange Reduce time delay associated with congestion
Reduced Energy & Environmental Impact	Reduce harmful emissions per unit of travel Reduce energy consumption per unit of travel Reduce new right-of-way requirements and community disruption Reduce fuel wasted Enhance efforts to attain air quality goals
Enhance Productivity	Reduce costs incurred by fleet operators Reduce cost and improve equity of fee collection Reduce delays and costs of regulating vehicles Reduce cost and improve quality of data collection Reduce travel time Reduce cost to transportation-dependent industries
Enhance Mobility	Improve accessibility to intermodal transportation Improve quality of travel options information Improve mode choice options Improve travel time predictability Improve transportation affordability Reduce travel stress

* From: National IVHS Program Plan, May 1994

Three major themes were prevalent among the users surveyed:

- Reduce congestion resulting from incidents, construction, special events, and recurrent congestion.
- Improve operation and surveillance capabilities of signalized intersections thereby improving coordination between signals and across jurisdictional boundaries, reducing congestion and improving air quality.
- Improve availability, flexibility, and efficiency of transit service.

Transportation users were united in the belief that providing traveler information to users was the most appropriate means of achieving the large majority of the goals. Similarly, jurisdictional members of the Steering Committee and other transportation stakeholders believed that, where traveler information had commercial value, those who share in the value should fund or participate in funding of the facilitating technology. Information sharing among operating entities and agencies was also expected to satisfy many of the system objectives.

1.2.2 Recommendation Guidelines for the Strategic Plan

Throughout the entire process of needs identification and matching, the Steering Committee continued to guide the study efforts to ensure that the study's final recommendations focused on the most pressing transportation issues in the County and took into consideration the existing communications, traffic surveillance and jurisdictional infrastructure to support modem traffic management. As a result of this work, a final set of recommendation guidelines was prepared, which is outlined below:

- Develop an ITS Strategic Deployment Plan for implementation in Maricopa County in the form of one, regional-scale project composed of a set of smaller, synergistic, modular projects, forming the steps to the completely fulfilled needs and established goals. The projects should focus on the following user services:
  - Traffic Signal Systems
  - Incident Management
  - Pre-Trip Traveler Information
  - Traveler Services information
  - En-Route Driver Information
  - Route Guidance Support
  - Improved Public Transportation Management
- The project should provide a set of implementation guidelines, to be followed by the area jurisdictions on a voluntary basis, providing step-by-step directions on the infrastructure deployment and upgrades necessary to achieve a modem and coherent system architecture for the region. This system architecture, developed in Task 6 of this project, will enable the partner agencies to fully benefit from the features of the Intelligent Transportation System, as they become available.
- One of the project recommendations should be development of a common set of plan and specifications, compliant with consensus architecture and technology. This set of plans and specifications would be utilized on a voluntary basis to achieve cost savings, improved overall ITS system reliability and maintainability and to support seamless interoperability for both the users and providers of ITS services.
- Transit-specific recommendations should be part of the Strategic Plan. Issues of transit schedule coordination and availability, transit vehicle preemption and tracking, transit user safety, and transit and traveler information availability for the transit user should be addressed.
- In addition, the project should address the issue of air quality in Maricopa County and propose mitigation measures which could be implemented and become part of the ITS infrastructure. Improving air quality is an issue of great importance in Maricopa County, and is explained as follows:

1.2.2-1 Air Quality Issues in Maricopa County

One of the significant benefits of deploying a regional-scale Intelligent Transportation System is the expected improvement of air quality in the region, due to reduced congestion. Maricopa County is one of -the largest and most rapidly growing areas in the country and decreased air quality, due in large part to recurring traffic congestion, is a high-priority issue. Although an improved transportation system should not be viewed as a panacea for the area's air quality problem, it will - through reduced traffic congestion, assist in lowering the area's overall level of vehicle emissions as well as mitigate emissions in specific, chronicly congested spots of the network. Lowering of vehicular emissions in "hot spots" on the network will be achieved by decreasing the time that a vehicle must remain within an area.

The January 31, 1991 Arizona Federal Implementation Plan (FIP) was promulgated by the U.S. Environmental Protection Agency, under court order. The FIP requires the Maricopa Association of Governments (MAG) to show that regional and microscale emission and concentration levels are improved when the Transportation Improvement Program (TIP) or the Regional Transportation Plan (RTP) is implemented. The inclusion of an aggressive air quality improvement program using ITS technologies would offer such a reduction in emissions and could serve as an important component in the overall air quality improvement battle.

Perhaps more importantly, such a program would reduce emissions, which are caused by highly congested traffic, in a relatively short time. In fact, the vision of the regional ITS system objectives includes proactive response to degrading air quality by:

- Recognizing the negative trend and its relation to traffic congestion
- Understanding corridors with less congestion, corridor cross section conditions, impact of longer green intervals along the corridor on overall traffic, with intelligent decisions made related to:
    - Timing plans change and/or
    - Diversion of traffic to a parallel, less congested corridor
- Combined corridor conditions sensors, ability of apparatus to communicate with the mobile traveler instantly plus ability to adjust signal timing plans will facilitate proactive response to air quality degradation

Maricopa County has unique problems when compared to the rest of the Country. It is appropriate that the ITS Strategic Plan recognize and address those unique problems. Maricopa County is a nonattainment area for carbon monoxide, ozone and PM-10. Over the past several years, many potential avenues for air quality improvement have been identified and implemented. Clearly, much of the air quality problem is transportation-related. There is no single solution for our air quality problem, however, ITS technologies have the potential of reducing automobile emissions. FHWA's algorithms clearly relate traffic flow volume and rate to air quality, greatly facilitating predictive modeling. For example, if the stops and delay on our roadways can be reduced, emissions will be reduced. In California, the FETSIM program reduced fuel consumption by 8.1% on those arterial streets where new traffic signal equipment and improved timing were implemented. Although this program did not model "before" and "after" emissions, one may assume emissions to be generally proportional to fuel consumption. Similar results were found in the Texas Traffic Light Synchronization (TLS) program, where fuel consumption was reduced by 9.1% overall on a wide range of roadways. Some involved re-timing an existing signal system. Others included providing a system where there had been none before.

In a recent project in Maricopa County, an 8% reduction in emissions was realized on Bell Road with the installation of a coordinated signal system and implementation of improved signal timing. Improvements of this level may be expected on arterial streets which carry approximately 40% of our vehicle-miles of travel, assuming an initial state of no pre-existing signal coordination. If an 8% reduction in emissions was obtained on these arterial streets, one could expect as much as a 3.2% reduction in emissions regionally, Even if the results were only half that much on a regional basis, a significant impact on our air quality problem would be realized. Similarly, the above statistics do not consider further improvements in emissions reduction through use of alternate corridors which results in further diffusing of the vehicular pollution. While the impact of diffusion on overall area air quality is unclear, it is believed that it may be significant, since heavy pollutants tend to inhibit diffusion of lighter pollutants. By minimizing heavier (molecular weight) pollutants, diffusion may be accelerated, thus potentially having a positive impact on area's air quality.

Many of the potential projects identified through this study process have the potential of improving air quality. Air quality is one of the most pressing problems facing Maricopa County. It is a regional problem that crosses jurisdictional boundaries. If ITS can reduce automobile emissions, all citizens will benefit. The fact that the reduction in emissions is accompanied by reduced motorists' stops and delay offers a cost savings resulting from reduced fuel consumption and vehicle maintenance. The value of the travel time reductions to motorists offers an additional savings. This potential to reduce emissions with an associated cost savings provides an opportunity for a common significant regional problem solving as the focal point for the early ITS projects. It increases the likelihood of obtaining funding, because the air quality problem will require funding to solve. Certainly, ITS improvements with their associated benefits makes them far more acceptable to the general public than some of the other potential solutions such as restrictions on driving.

13 Project Vision

Based on the guidelines presented in **Section 1.2.2** and on the understanding of the National ITS Program Plan, a single, full vision implementation plan is recommended for Maricopa County. The plan, composed of number of implementation phases, addresses all seven areas of the U.S. DOT ITS Core Infrastructure, and provides a blueprint for full implementation of ITS services in the region.

The following are the envisioned functional capabilities of the fully implemented system in Maricopa County:

- Modernized, interoperable, area-wide TOCs
- Traffic monitoring on major corridors
  - Ability to acquire, process, and assess information, and provide appropriate control feedback
- Proactive traffic management to contain pollution before it exceeds EPA standards, by:
  - Timing plan adjustments
  - Traffic redirection
- Consolidation of all area traffic and transit data for distribution to travelers and major users (public media, fleet dispatching centers, etc.)
- Direct distribution of corridor conditions and hazard information to users
- Direct Radio Digital Data Services (RDDS)
- Variable Message Signs
- Highway Advisory Radio
- Intelligent RF tags with in-vehicle display/alarm
- Indirect Advanced Traveler data distribution through privatized ATIS

- Cellular telephone
- Direct user dial-up (voice/data)
- Interactive TV
- I-IAZMAT early warning to jurisdictional TOCs
- MAYDAY traveler safety/positive and affordable "MAYDAY" support for travelers
  - Dial-up cellular telephone (voice or automated digital forwarding to security center)
- Standardized electronic fee collection
- Improved public transit vehicle dispatching and coordination with traffic management
  - Including schedule and status information distribution to service centers
- Operational and maintenance costs savings options for jurisdictions
- Emergency backup of the traffic control functions
- Traffic/FMS/Transit coordination
- Quick response to incidents
- Affordable extended services to users
  - Available through a variety of service channels

The-implementation of the Strategic Plan will be accomplished in 3 phases. Phase 1will provide full traffic surveillance, incident management, and interoperability between ITS systems. Phase 2 will provide a fully expanded ATIS capability, including:

- Core functions of:
  - Corridor traffic conditions
  - Corridor hazards (detection and warning)
  - Transit schedule
  - Information distribution to information brokers, end user distributors, and fleet operating centers
  - Variable Message Signs (VMS)/Highway Advisory Radio (HAR)

- Privatized distribution of information to end users through:
  - Auto-voice
  - Auto-graphics
  - Kiosks
  - Interactive TV
  - Other

- MAYDAY emergency request on incidents
  - Monitored by third party for a fee or service such as:
    - Cellular telephone
    - Security center (e.g. Brinks/Westinghouse Security)
  - Mechanical and other non-accident related hazards by service center
    - Incident information passed to associated jurisdictional center for incident notification and removal monitoring

Phase 3 will comply with core electronic fee collection/electronic toll and traffic management (ETTM) capability. Phase 3 will complete the core capability stated as important to ITS success by FHWA, as applicable to area needs..

1.3.1 Core Infrastructure Adherence

The US Department of Transportation has established a set of seven features forming the "core infrastructure" for deploying ITS traffic management and traveler information services in metropolitan areas. The definition of these seven features is intended to focus near-term deployment decisions being made in metropolitan areas and to maximize future opportunities to implement widespread, advanced ITS user services. The seven core infrastructure features are:

1. Regional Multimodal Traveler Information Center
2. Traffic Signal Control System(s)
3. Freeway Management System(s)
4. Transit Management System(s)
5. Incident Management Program
6. Electronic Fare Payment System(s)
7. Electronic Tolls, Fee Collection System(s) for use on infrastructure (such as tolls, airport dwell/parking, congestion pricing, etc.)

This study's User Service Plan and ultimate Strategic Plan recommendations follow the core infrastructure guidelines as they apply to the unique needs of the Maricopa County transportation system. The full text of *the Core Infrastructure Features for ITS Deployment in Metropolitan Areas* is included in the **Appendix.**

In line with the spirit of the Code guidelines, the recommended project should be modular in design: various parts of the system can be deployed on an as-needed basis and as funds become available. **Table 1.3.1-l** presents a brief outline of the technology implementation and project constraints for the proposed Early Deployment Plan:

TABLE 1.3.1-1
TECHNOLOGY IMPLEMENTATION OUTLINE

Core Feature	Implementation Attributes and Constraints
Regional Multimodal Traveler Information Center (RMTIC)	*Based on voluntary city participation.*
	Provide equal access to information and data input
	Provide automated connection between TOCs and the Clearinghouse (wireless/SONET)
	Possible initial information input solution: equip every TOC desiring to participate with a PC with software and modem. Have TOC operators input needed information (as determined by the input form within the software) which then can be processed and distributed. This limited application of a Wearinghouse" could be implemented immediately, and upgraded with the advancing ITS infrastructure.
	Information gathered from TOCs: incidents (including accidents), road closures, special events, traffic conditions along corridors, etc.
	Information distributed to the public via cable, TV, telephone (both voice and dial-up services like BBS or Internet), radio, kiosks
	Build on FMS foundation, include current efforts

TABLE 1.3.1-1
TECHNOLOGY IMPLEMENTATION OUTLINE
(continued)

RMTIC - continued	*Determine location of the Clearinghouse*
	Fee-based and free information available to private organizations
Traffic Signal Control Systems	*Traffic Signal Control Systems are in various states of deployment.*
	Work out a plan with the local air quality enforcement/monitoring agency to potentially monitor and react to air quality degradation by changing signal timings.
	Real time control/signal system upgrade
	Use CCTV for traffic surveillance (image used for analysis ofproblems and incidents/management
	TraffiCam™ (or euivalent) for parameter extraction if no loops for corridor conditions monitoring
	Use SmartSonic™ as alternative to inductive loops, based on ADOT deployment testing
	Potentially use AutoScope™ where economical for expanded lane coverage
	Use Variable Message Signs for early incident notification/warning
Freeway Management System	*Already partially in-place: ADOT has deployed a Freeway Management Center which became operational in September of 1995. The system should provide information link between FMS and the RMTIC. The FMS should develop signal coordination with surface street progression at freeway interchanges. Coordinated emergency response and special event coordination should be developed.*
Transit Management System	*Transit Management Systems are being deployed with electronic fee collection.*
	Focus on information sharing & exchange between the transit system operations and the RMTIC. The improvements to transit management and operations will be performed by the transit authority according to its own schedule. ITS will also facilitate transit vehicle preemption to meet schedule and schedule information distribution to transit users.
	Responsible for deploying its own A VL/A VM (GPS recommended)
	Integrated with network: provides schedule and performance information to ATIS; receives corridor conditions and hazard information from traffic management

TABLE 1.3.1-l
TECHNOLOGY IMPLEMENTATION OUTLINE
(continued)

Incident Management Program	*Incident detection and surveillance. Incident evaluation on main corridors through CCTV*
	Emergency services coordination and clearance evaluation. Coordination of incident removal.
	MAYDAY support/coordination through private partnership with cellular communications company and security monitoring systems (as have been implemented by Ford Motor Company)
Electronic Fee Payment System	*Smart Card and credit card use for bus fare payment*
Electronic Fee Collection System (s)/Electronic Toll and Traffic Management (ETTM)	*Fee collection for parking at Sky Harbor airport and taxi management*
	Fee collection for parking at Suns Stadium and other major facilities
	Potential toil collection on South Mountain Freeway
	CVO clearance and safety

SECTION II - STRATEGIC PLAN IMPLEMENTATION

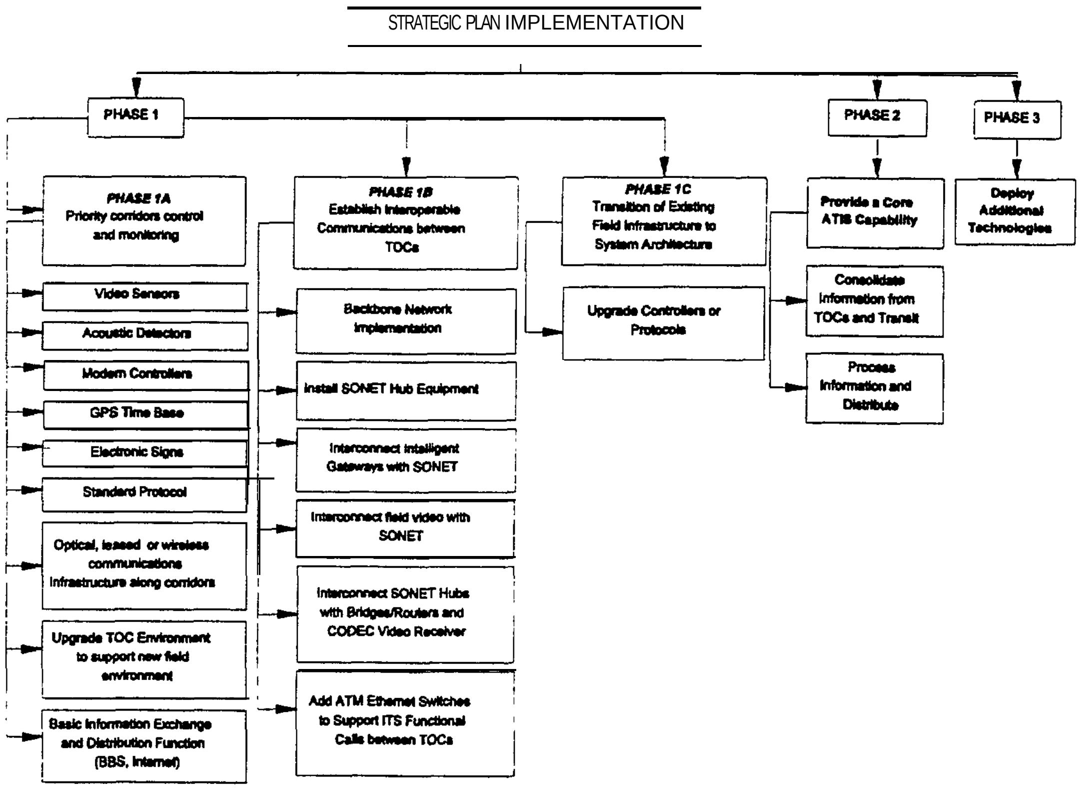
2.1 Recommended Plan

A strategic plan is recommended for Maricopa County which identifies a single project, composed of set of smaller, incremental projects, to achieve the required ITS services and recommended system architecture. The plan recommends providing:

- Adoption of a common architecture and standards supporting incremental build-out of ITS capabilities and services.
- Field infrastructure upgrades to support needed sensor information to determine traffic congestion on corridors and rapid detection and response to incidents.
- Upgrades to jurisdictional Traffic Operations Center (TOC) environments to provide needed processing hardware, software and display equipment to support field infrastructure upgrades.
- Implementation of a communications infrastructure to support interoperability between TOCs and to support improvements in traveler information support to the public and commercial vehicle operations (CVO). Development of a detailed communications plan for Maricopa County is recommended.
- Interoperability between traffic and transit management.

Each phase of the plan will provide a building block which, upon completion, will meet the consensus needs of the Maricopa County transportation system. A summary flowchart depicting plan implementation is shown on **Figure 2.1-1.**

Figure 2.1-1
Strategic Plan Implementation



The Strategic Plan is designed to support the current and planned improvement initiatives of each city/jurisdiction. These improvements were discussed in Tech Memo 6/7, and include:

TABLE 2.1-1
ONGOING AND PLANNED TRANSPORTATION PROJECTS IN MARICOPA COUNTY

Project/Study	System
FMS	ADOT FMS first phase completed with TOC; planned to ultimately serve more than 200 miles
ADOT Strategic Plan for IVHS	Provides a state-wide ITS communications plan supporting interoperability between ITS segments and services
Phoenix Transit	Bus Card Plus Program including debit and VISA cards for electronic payment; AVL with GPS; on-board automatic voice announcement
ADOT RDDS	Demonstration study underway
MAGIC	Regional signal system coordination; integration of regional system with ADOT FMS; Development of a regional ATIS
Highway Performance Monitoring System	MAG database system with GIS
Rhodes-ITMS	University of Arizona algorithm development for coordinated freeway/surface interchange signals and ramp meters. Tempe is a beta test site.
City of Scottsdale	Leased telephone alternatives evaluation; vehicle detection and CCTV evaluation; motorist information subsystem evaluation; city traffic control center planned; regional TOC interface evaluation
City of Glendale	ATMS under design
City of Phoenix	New city-wide computerized traffic signal system under design; fiber-optics in downtown area; wireless and cooperative public/private project with fiber optics providers under evaluation. "Smog Dog" evaluation test.
City of Mesa	Central system software being upgraded support TS-2 standard. The City is evaluating video for traffic management.
City of Tempe	Special event control system funding requested
Sky Harbor Airport	Modernization utilizing Electronic Toll and Traffic Management (ETTM) technology

2.2 Geographic Boundaries

The recommended project covers the entire area of Maricopa County with specific focus on the area's major corridors, such as those identified in the MAGIC (July 1994) study. The MAGIC study evaluated a set of Valley arterials to receive major improvements, based on the following criteria:

- Traffic characteristics along the arterial
- Congestion levels
- The number of jurisdictional systems along the arterial
- Signal spacing
- Speed transition (including school zones, high pedestrian areas such as CBD or university, residential areas, or railroad crossings)
- Variation in cycle lengths between jurisdictional boundaries
- Level of regional travel (the number of long trips which travel on an arterial through several jurisdictions)

- Regional coverage (providing good coverage of the metropolitan area and complimenting the existing and planned freeway system)
- Level of signal control (non-coordinated, time-base coordinated, or system control)

Ten arterials selected by the study are listed in **Table 2.2-l:**

TABLE 2.2-l
SELECTED MAGIC IMPROVEMENT CORRIDORS

	Arterial	Jurisdiction(s)
1.	Baseline Road, from Gilbert to 5 1st Avenue	Mesa, Tempe, Phoenix
2.	Broadway Road, from Val Vista to Central	Mesa, Tempe, Phoenix
3.	Indian School Road, from Pima Road to 99th Avenue	Scottsdale, Phoenix, ADOT, MCDOT
4.	Bell Road/Prank Lloyd Boulevard, from Pima Road to Grand Avenue	Scottsdale, Phoenix, Glendale, ADOT, MCDOT, Peoria
5.	Glendale Avenue/Lincoln Drive, from Scottsdale Road to 99th Avenue	Scottsdale, P.V., Phoenix, ADOT, Glendale
6.	59th Avenue, from Union Hills to I-10 Interchange	Glendale, ADOT, Phoenix
7.	Arizona Avenue/Country Club, from McDowell Road to Chandler Boulevard	Mesa, ADOT
8.	44th Street/Tatum Boulevard, from Bell Road to McDowell Road	Phoenix, P.V.
9.	Thunderbird Road/Cactus Road, from Pima Road to 99th Avenue	Scottsdale, Phoenix, ADOT, Glendale, Peoria, MCDOT
10.	University Drive, from Power Road to 44th Street	Mesa, MCDOT

* P.V. - Paradise Valley

The selected MAGIC corridors are shown for reference on **Figure 2.2-l. The** deployment of ITS technology is likely to involve one or more of these routes. For planning purposes, these routes were carried forward for the derivation of costs, however, this project recommends that the initial phases strategic plan deployment reconsider the initial corridors for implementation. It is suggested that additional emphasis be placed on arterials parallel to Valley freeways, where FMS elements are currently in place. As the technology implementations are tested and proved in the field, their deployment should be expanded to cover additional corridors, which will be chosen through interjurisdictional cooperation.

2.3 Implement Communications, Sensors, Traffic Control and Traveler Information Dissemination along Corridors.

2.3.1 Phase 1A: Field Implementation

The first increment in the strategic plan is to design, install, integrate and test traffic sensors, and modern controllers along priority corridors within Maricopa County, thus providing initial capability for monitoring and control of each corridor segment by the responsible jurisdiction. Candidate corridors have been tentatively identified in **Section** 2.2. Based on recommendations of Tasks 6 and 7, the following technology should be considered for deployment along the chosen corridors:

- Video sensors such as TraffiCam™ (or equivalent) for volume, speed, presence and classification.
  - Also utilized for signal control
  - Strategically deployed along the corridors to provide critical information on traffic congestion and to support incident detection.

- Passive-acoustic detectors such as SmartSonic™ (or equivalent) along priority corridors to compliment video sensors in areas where video sensors may be obstructed or lighting may be a problem.

- Modem controllers along the "smart" corridors which are monitored in real time as a source of traffic information and can be controlled as necessary through selection of and adjustments to timing plans.

- Real time coordination for all "smart" corridor controllers by utilizing GPS time base which will further support infrastructure-to-vehicle time base coordination, as recommended in Task 6/7 report.

  - This facilitates event coordination as well as location coordination between infrastructure and vehicles such as public transit and emergency vehicles. For example, high-accuracy navigation and timing allows transit vehicles to preempt signals only if they are late. This is accomplished by real-time coordination between transit dispatching and traffic control and generally includes:

    - GPS time coordination between vehicle and traffic control
    - Accurate vehicle location reporting
    - Knowledge by the traffic system if the transit vehicle is behind schedule by an amount to justify traffic perturbation.

- Installation of surveillance CCTV along the corridors in such a manner as to support incident and traffic congestion evaluation.

- Electronic signs to communicate corridor status and to advise alternate corridor(s), including dynamic routing signs (e.g. PathFinder™ or equivalent),

- Implementation of national ITS standard protocols along SMART corridors as the starting point for an area wide protocol standardization, even if protocol conversion may be necessary at existing TOCs as an interim approach.

  - Where the national protocol standard (such as NTCIP) is in draft form, use the version which has the highest probability of evolving to the national standard (even though minor modifications may be necessary to achieve compatibility with the final standard).

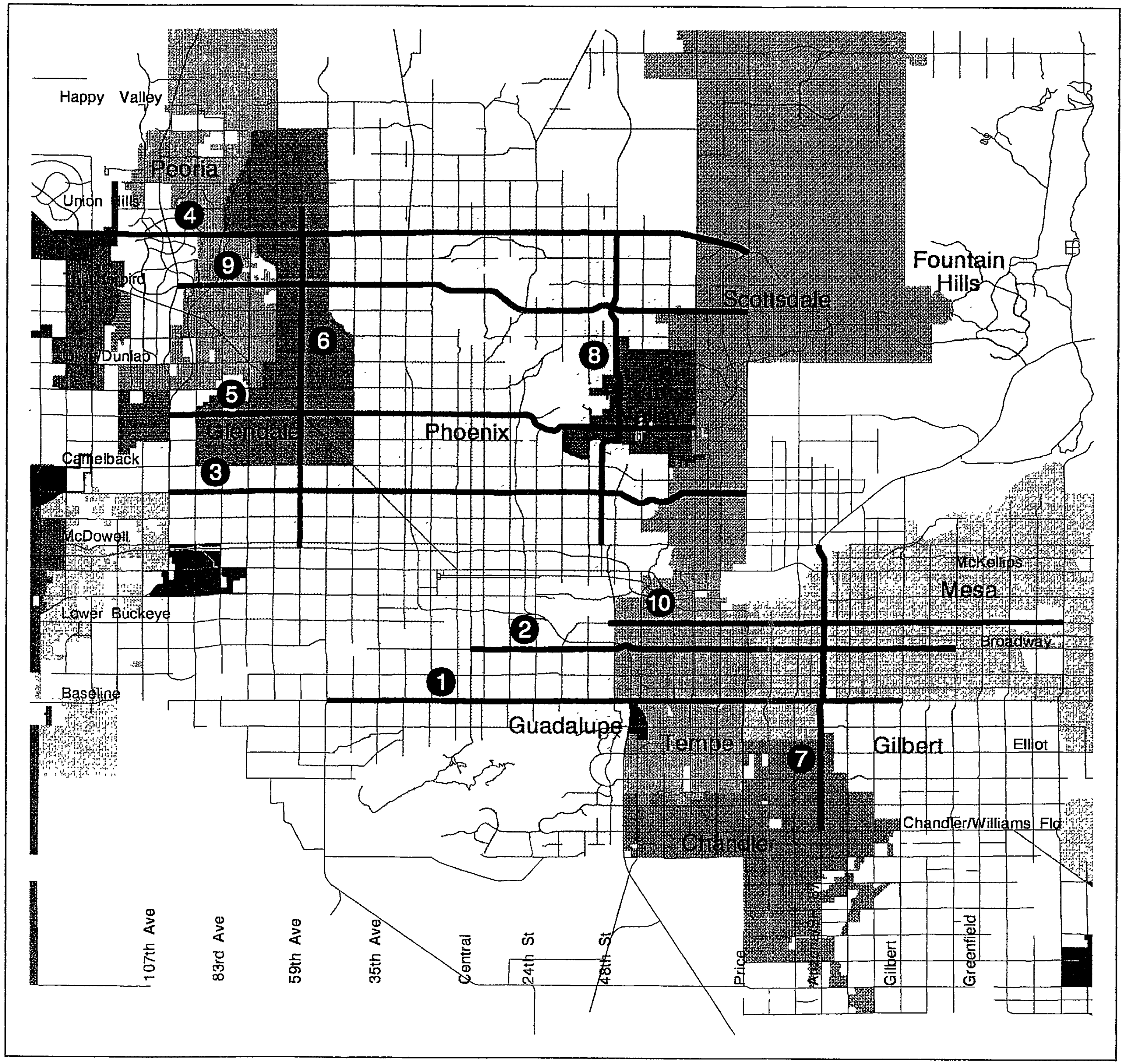
- Integration of controllers with communications infrastructure necessary to support the surveillance, monitoring, and control objectives.

  - Develop the appropriate infrastructure along corridors in such a manner as to support formation of a peer-to-peer, backbone communications network. The possibility of utilizing some of the unused FMS fiber should be investigated.

  - Where traffic conditions and business interruption will not allow fiber installation, use wireless seamless interconnect.

Figure 2.2-1

MAGIC Corridors



1 0 1 2 3 4 5 Miles

Legend

MAGIC Corridor

Kimley-Horn and Associates, Inc.

LEE ENGINEERING

- Termination of controller communications within each jurisdictional area into a standard jurisdictional communications gateway as described in Task 6/7 report.
  - Size the gateway for fully implemented field environment
  - Integrate the gateway with the TOC via optical communications link

- Within the TOC, terminate the gateway into a DS-l/Ethernet bridge/router

- Upgrade the TOC information processing and display environment to accommodate the new field environment.

  - Where necessary, upgrade the TOC with medium hybrid control capability.

Figure 2.3.1-1 illustrates the Phase 1 A approach. In addition to the control and surveillance infrastructure deployment along the priority corridors, Phase 1 A should incorporate a basic ATIS function. This basic function would provide for corridor traffic conditions information distribution to the users using simple interfaces such as telephone, dial-up service, (e.g. a public access BBS system), and/or via the Internet.

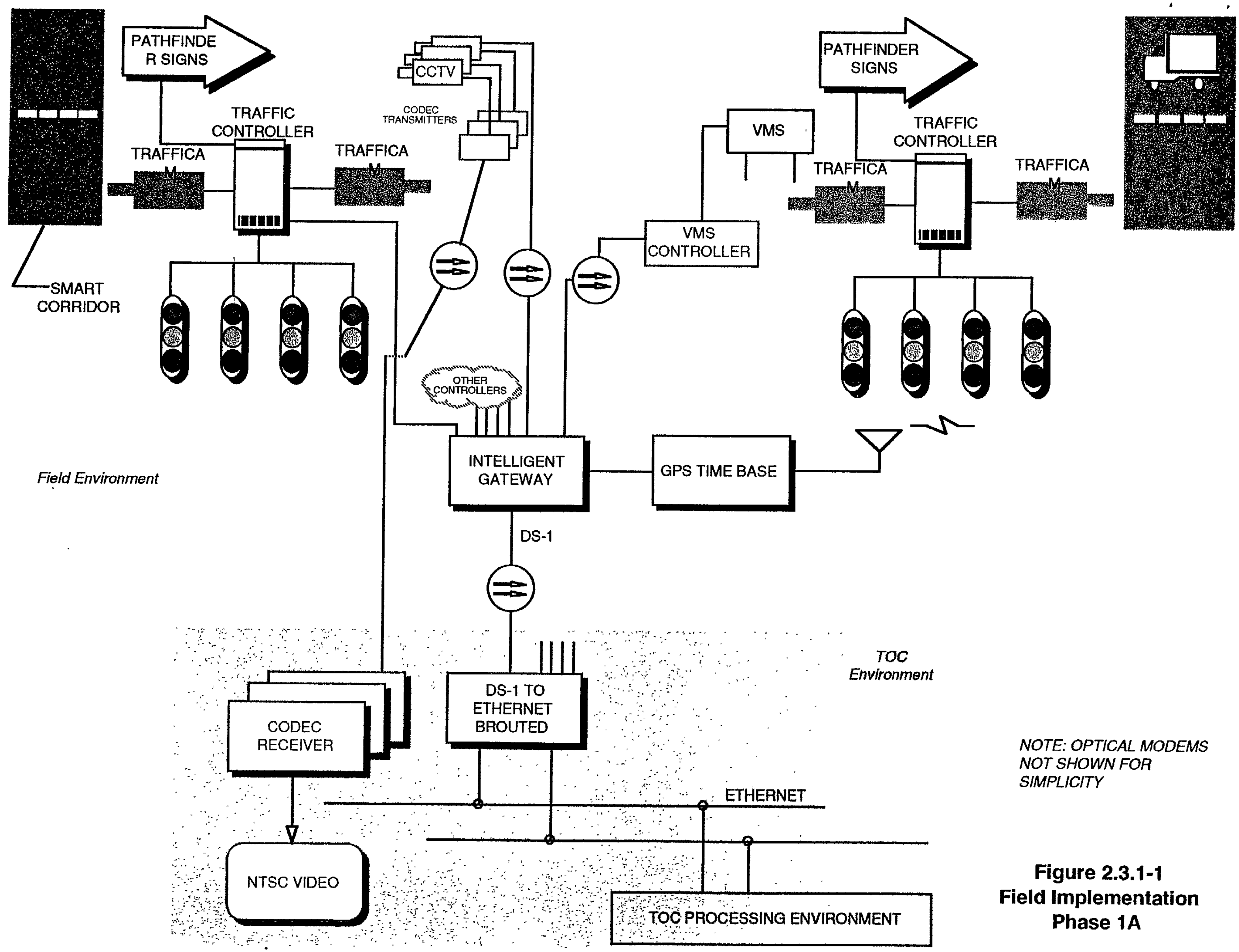
2.3.2 Phase 1B: Creating Interoperable Communications Between Traffic Operations Centers (TOCs)

Phase 1B will consist of completing any future communications path, not established by segment corridor implementation, facilitating installation of the SONET backbone. With the completion of Phase lB, the following base capability will be available:

- Smart corridor traffic condition monitoring, pollution monitoring and incident detection
- Ability to communicate with travelers on the corridors through electronic signs
- The ability to share video along the corridor with all traffic operations centers
- The ability of a jurisdiction to open its gateway for control and monitoring by another TOC:
  - As backup, in case of TOC failure
  - As cost saving at night and on weekends by reducing/eliminating operational staff costs
  - As cost saving by sharing in common maintenance
- The ability to share functionally oriented processed data between TOCs and with transit management center(s):
  - Transit schedules and status (virtual) LAN
  - Corridor virtual status (virtual) LAN
  - Emergency coordination (virtual) LAN
  - Others as required to a DS-3 data rate (4 to 8 LANs, depending on data load analysis)
- The ability to provide voice communications coordination for operations, planning and maintenance between operations centers

SONET microwave may be used in areas where further in-ground installation **is** not feasible. A folded ring may be used for initial interoperable capability. **Figure 2.3.2-l** illustrates the Phase IB build-out, which includes:

- Backbone network implementation
- Installation of SONET hub equipment
  - Sized to accommodate 15 year communications needs projection
  - Consider integration of other agencies' communications needs, including transit, emergency services, public works, etc., to reduce cost



NOTE: OPTICAL MODEMS NOT SHOWN FOR SIMPLICITY

Figure 2.3.1-1
Field Implementation
Phase 1A

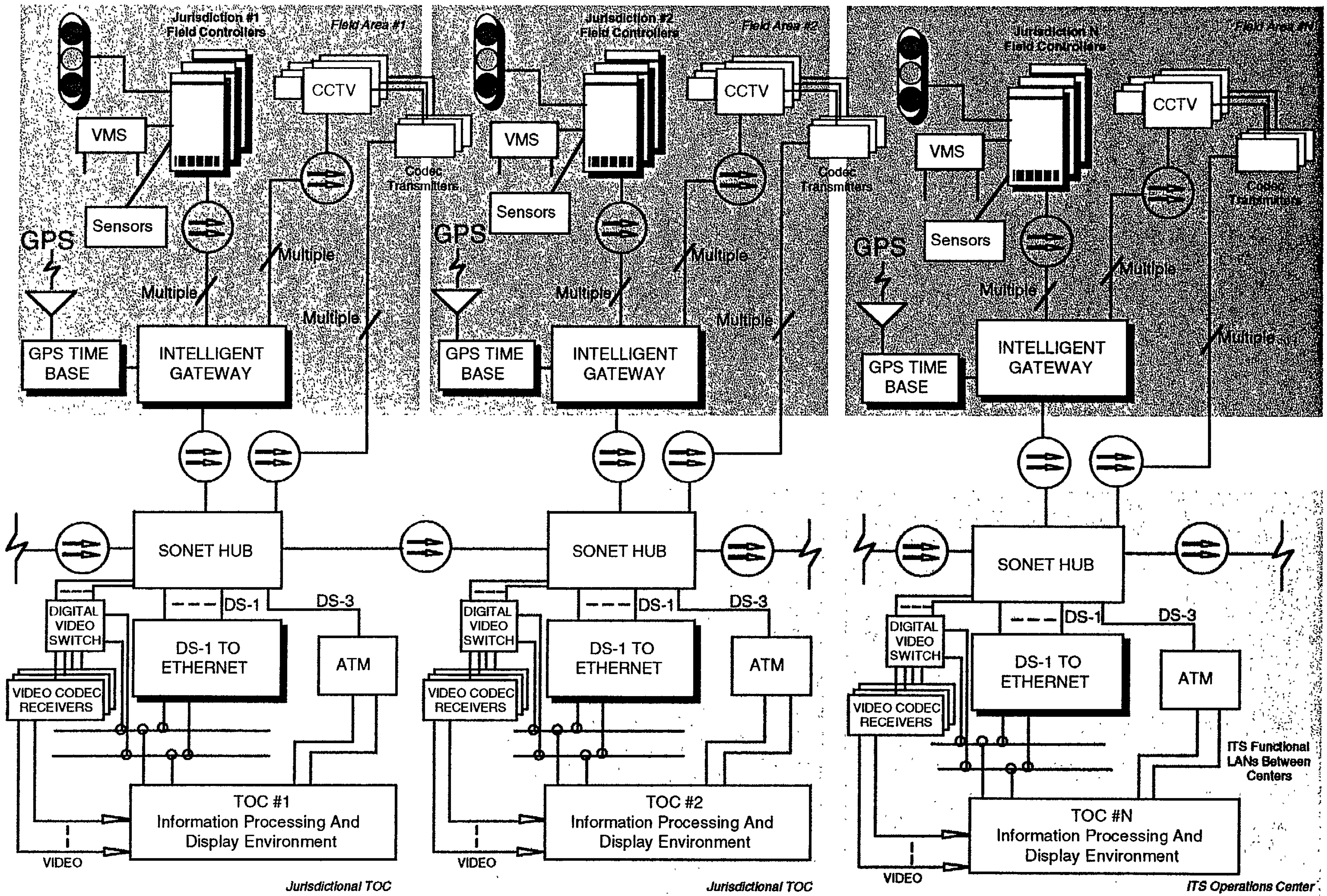


Figure 2.3.2-1
Phase 1B
Communications Backbone

- Interconnecting the intelligent gateway with SONET
- Interconnecting the field video CODEC with SONET
  - Allows network distribution of video and thus sharing of surveillance video
- Interconnecting the SONET hub with bridge/router and CODEC receiver equipment
- Adding ATM Ethernet switches to support ITS functional calls between centers

It should be noted that two types of virtual LANs are established:

- Field monitoring and control
- ITS functional virtual LANs

The functional virtual LANs facilitate data distribution without "mixing" functions. For instance, one LAN may become an extension of public transit dispatching with transit schedule, transit vehicle position and time (early/late) comparison against schedule provided. This implementation may be used by TOCs for supporting:

- Permissive transit vehicle signal preemption if late
- Transit vehicle coordination during special events based on CCTV assessment of traveler queues
- Transit vehicle accident removal coordination

Similarly, access to the transit functional LAN by a centralized ATIS operations center provides all critical data needed for ITS information distribution to the public, with the exception of "yellow pages" and reservations links to hotels, restaurants, etc.

23.3 Phase 1C: Transition of Existing Field Infrastructure to the System Architecture

Phase 1C consists of the integration of the existing field infrastructure with the gateway. This phase may include the upgrade of field controllers to types recommended for the common architecture. Where controllers are upgradeable to a common protocol, they may be maintained.

As jurisdictions transition to a common field protocol, they will become capable of "full membership" in the peer-to-peer architecture. To the extent that jurisdictions maintain an incompatible protocol and/or control strategy, they are capable of "partial membership" in the peer-to-peer architecture. Partial membership means:

- Ineligibility for:
  - Back-up by other TOCs
  - Operational data sharing with'other TOCs
  - Common maintenance monitoring and support

- Eligibility for:
  - Video sharing
  - Functional LAN information sharing (i.e. processed ITS data sharing)
  - High level TOC-to-TOC coordination
  - Time coordination

The system architecture can interoperate at various levels based on peer-to-peer common capability. **Figure 2.3.3-1** summarizes Phase 1C configuration.

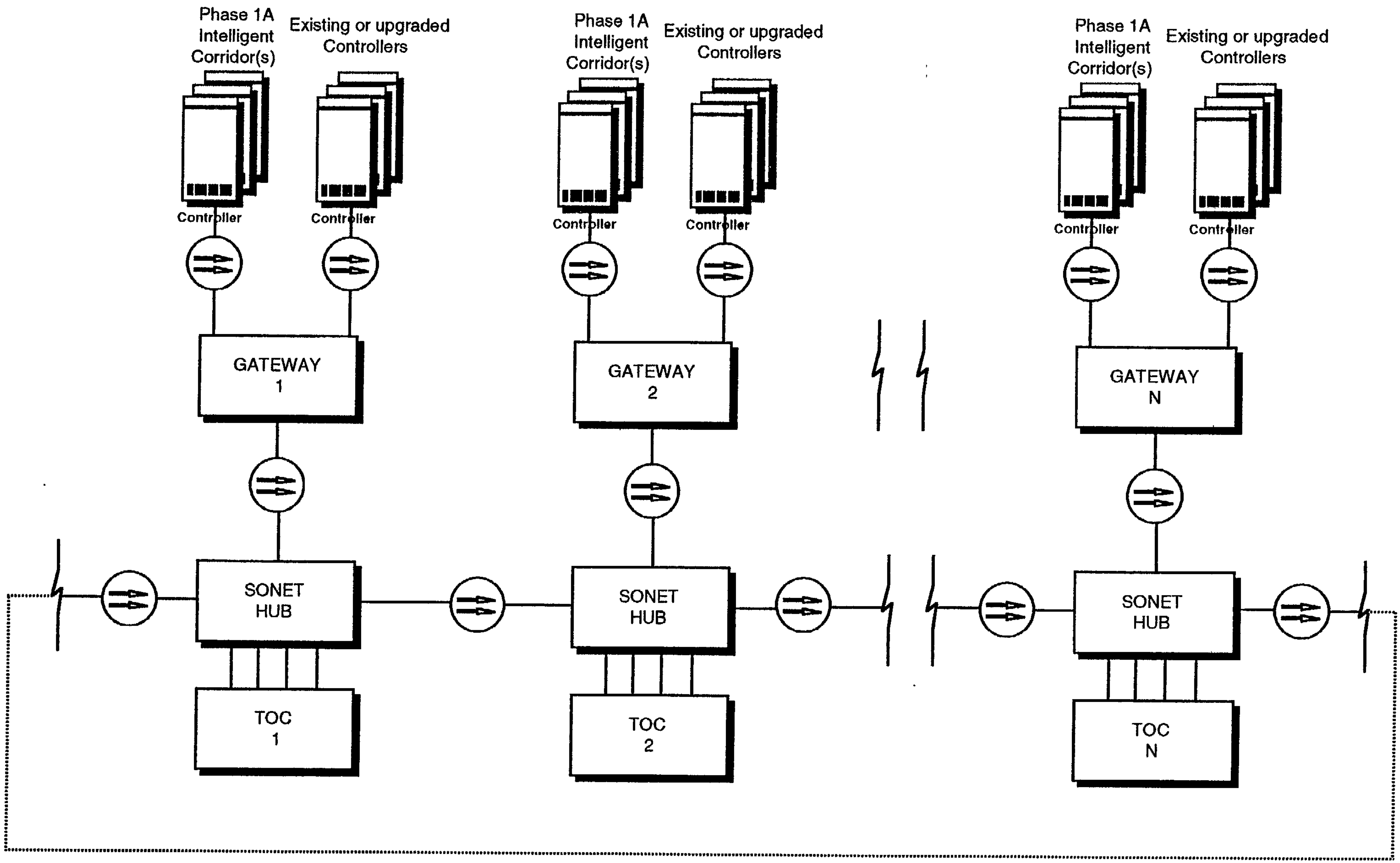


Figure 2.3.3-1
Phase 1C
Integration of Current Traffic Monitoring and Control Infrstructure into the System Architecture

2.4 Phase 2: Expansion of ATIS

Phase 2 provides a core ATIS capability integrated with the Maricopa County network. The core ATIS capability will include the following functions:

- Consolidation of area ATIS reports from jurisdictional TOCs and transit operations centers
- Preparation of consolidated information on corridor conditions and hazards
  - Provide interface to RDS subsystem of FM radio stations (FM subband digital broadcast)
    - Transmission of corridor conditions to in-vehicle route guidance systems
  - Provide interface to other public broadcast media for use and distribution to viewers/listeners:
    - TV
    - AM radio
    - FM radio
    - Cable TV
  - Provide interface to cellular telephone operations center providing traffic conditions reports
  - Provide interface to a private security monitoring service (such as Westinghouse Security Services) for monitoring cellular alarms (same as homes) and reporting "MAYDAY" to associated TOCs and for incident coordination via ATIS link
    - Private users or commercial companies pay security monitoring cost (similar service provided by Ford Motor Company for purchasers of Lincoln cars. This is a growing trend in ITS MAYDAY services).

Each jurisdiction provides corridor conditions data over the virtual LAN assigned to functional ATIS data exchange. The "core" ATIS center consolidates corridor status data for user distribution. Similarly, transit system(s) schedule and status data is also received and combined by the "core" ATIS center. The core ATIS center provides consolidated ATIS information over the network for jurisdictional use. **Figure 2.4-l** presents the core ATIS layout.

- The core ATIS will partner with a privatized function to provide full service ATIS distribution to users.
- Perhaps use a I-900 telephone service for fee-based information services
- Pay subscriber service for graphics map and communications interface software to present corridor status on personal computer via dial-up modem
- The privatized element of ATIS will be primarily funded by:
  - Yellow Pages coverage (paid by advertisers)
  - Reservations made (paid by hotels/restaurants)
  - Small, affordable fees to the users
- Use Internet for advertising of services and information retrieval

The core ATIS will supply basic traveler information which is created by ITS "core" functions such as traffic surveillance, hazards warning, traffic management, and transit management. Information of commercial value such as Yellow Pages will be privatized. Where information transfer to users is of primary benefit to the users, it will be privatized. Where the infrastructure derives a clear benefit, the information transfer to the user will be subsidized (e.g. use of FM subband to provide corridor status data to route guidance systems).

Perhaps, with ADOT's current plans for extended ATIS services, an ATIS subsystem of the ADOT FMS could serve as the initial consolidated (core) ATIS element of the integrated Maricopa County ITS system.

2.5 Phase 3: Deployment of Additional Technologies

During Phase 3, several additional technologies will be deployed:

- Electronic fee collection: under a separate project Sky Harbor International Airport will implement electronic toll tags for parking fee collection and taxi management at the airport. Airport Authority - Maricopa County partnership will standardize an RF tag which will meet the needs of commercial, private, and public transit vehicles and taxies within the area. Electronic toll and traffic management readers with Sky Harbor airport electronic tag compatibility will be encouraged for use at the Suns stadium and at other future major transit centers.

    - RF tag readers will be deployed at entrances to major commercial corridors for detection of HAZMAT or commercial vehicles.
    - RF tag readers will be deployed strategically along major corridors to support:
        - Use of RF tags of opportunity as probe vehicles
        - Calibration and verification of public transit vehicles position
        - Hazards warning to vehicles with toll tags and not equipped **with** route guidance
    - Where future toll tags are required, the standard tags will be used

Phase 3 complies with core electronic fee collection/electronic toll and traffic management (ETTM) capability. Phase 3 completes the core capability stated as important to ITS success by FHWA.

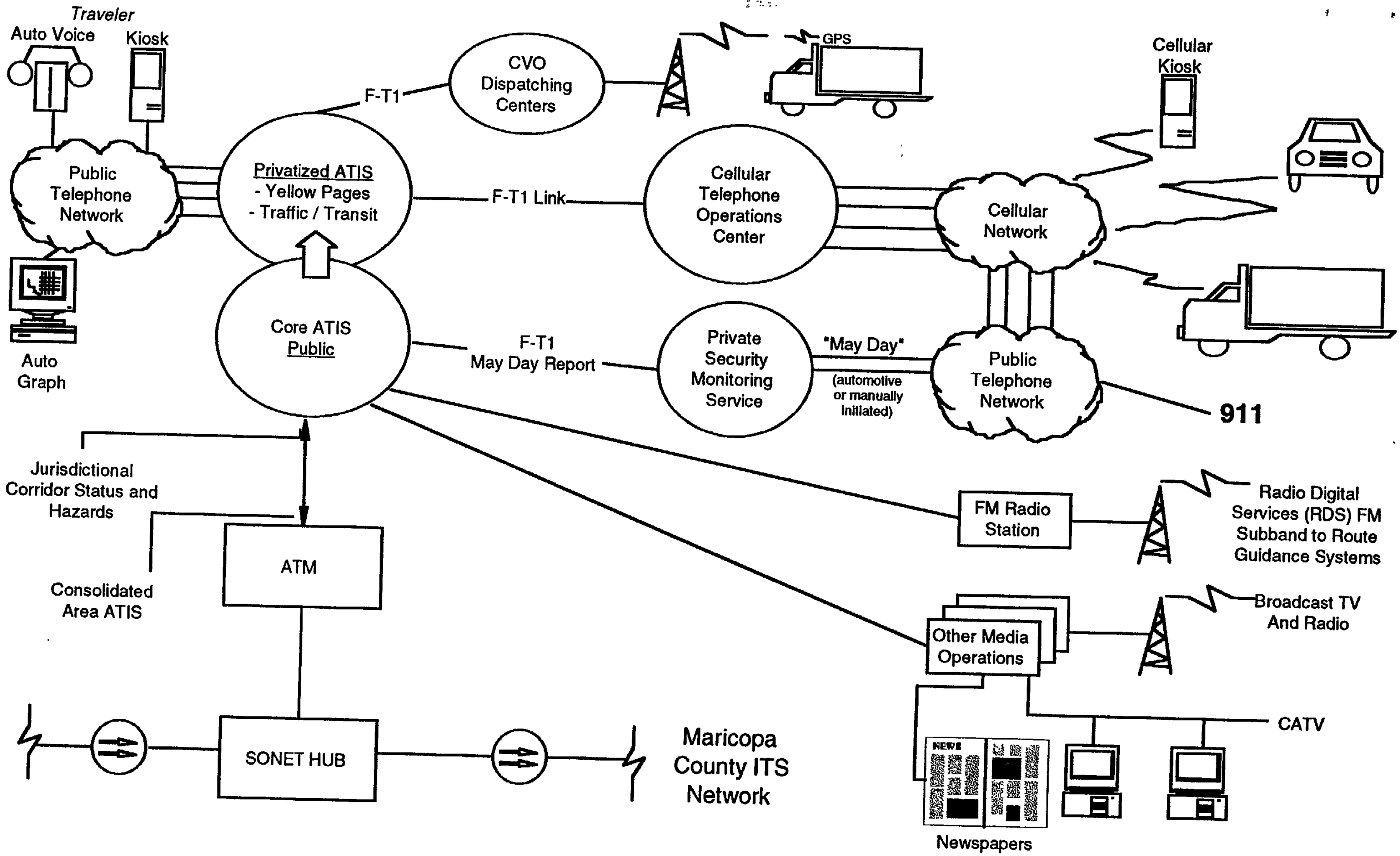


Figure 2.4-1
ATIS Core Capabilities

SECTION III - IMPLEMENTATION

3.1 Cost

This project is presented in 3 phases, of which Phase 1 consists of 3 parts. A rough order of magnitude project cost is presented for phases I A, lB, and 2 of this project. A preliminary analysis of the requirements is performed to cost each phase. A cost range is provided for these phases with discussions on potential implementations within the range.

Cost detail is provided to allow parametric analysis with respect to the derived requirements and assumptions. Consideration of the assumptions must be forefront in any analysis of these estimates, with a reminder that the cost objective is to obtain a rough order of magnitude cost estimate for the project.

A cost estimate is provided for a pre-Phase IA communications analysis. This analysis may present findings that will change assumptions made throughout this analysis and may affect the costs estimated. This analysis is expected to detail specific functional requirements and hence data requirements. For example, the number, placement, and type of CCTV camera and quality of received video image will affect both the arterial communications design and the regional communications backbone design.

The cost breakdown for each task will generally adhere to the following structure:

- Construction Cost
- Engineering Cost
- Capital Cost
- Software Development Cost
- Operations and Maintenance Cost

Where cost estimates are presented with less fidelity, the cost structure will combine cost elements, e.g., construction cost and engineering cost might be presented as a combined cost or only a total cost will be presented. For clarification of the cost structure, the following definitions are provided:

- Construction cost - this is the cost for site design and installation including labor costs.
- Engineering cost - this is the cost for analysis and design, integration, test, and system acceptance of the subsystems and system.
- Capital cost - this is the cost for material procurement.
- Software development cost - this is the cost for the design, coding, integration, checkout, and acceptance of the software.
- Operations and maintenance cost - this is the cost for operator and maintenance labor hours, operating expenses, repair and replacement costs, and any warranty costs for 20 years.

Where specific cost data are not available, the following cost estimates are used. The basis for these estimates are from similar transportation proposals and projects.

- Construction cost - 6%
- Engineering cost - 15%
- Operations and maintenance cost - 10%

3.1.1 Pre-Phase 1A

This phase is conducted prior to the deployment project. It is an extensive analysis of the communications system in Maricopa County and the transportation needs identified in this study. The analysis will examine Maricopa County and recommend a communication system that best addresses the transportation communication requirements of Maricopa County and is consistent with the architecture framework presented in this study. The results of this analysis may present findings that are inconsistent with the assumptions made in this analysis. Thus, the cost estimates provided in this study may change.

The analysis would examine functional requirements and hence data requirements. These data requirements might affect communications between TOC's and field controllers as well as the regional communications backbone. An example is a monitoring requirement for additional arteriais with a full-motion video requirement. This might affect the communications backbone data rate and design as well as communications hubs, and the local TOC requirements.

Throughout the remainder of this analysis, many assumptions are made. It should be noted that they are made in lieu of the recommended pre-Phase 1A. This pre-Phase IA design is expected to cost $200K of engineering.

3.1.2 Phase 1A

This phase is focused on the integration of priority corridors in Maricopa County.

The priority corridors identified in the MAGIC study are analyzed as representative priority corridor candidates. The costs developed from this analysis will provide a range for priority corridor integration using a per mile cost factor. The costs are developed to allow parametric analysis such that costs of alternative corridors and/or variations of the MAGIC corridors can be estimated.

The total length of the MAGIC corridors is approximately 186 miles and involves approximately 325 intersections and 9 jurisdictions. Where applicable, the number of miles and intersections will be used to estimate aggregate phase costs.

3.1.2.1 Phase 1A Requirements

In order to integrate the priority corridors, functional requirements for this phase are listed below.

1A-1 A system design shall be developed to integrate the priority corridors.

1A-2. Machine vision sensors (e.g., TraffiCam™) shall be integrated if installed along the corridors to provide information on traffic congestion and to support incident detection where other sensors are unavailable or to support technology testing.

1A-3. Sonic sensors (e.g., SmartSonic™) shall be integrated if installed along the corridors to complement video sensors in areas where video sensors may be obstructed or lighting may be a problem.

1A-4. Controllers shall be installed or upgraded where necessary along the corridors to provide real time monitoring for traffic information and shall be controlled as necessary through selection and adjustments to timing plans.

1A-5. Controllers along the corridors shall provide real time coordination using GPS time base.

1A-6. Closed-circuit television (CCTV) shall be integrated if installed along the corridors to support incident and traffic congestion evaluation.

1A-7. Electronic signs, including dynamic routing signs such as PathFinder™, shall be integrated if installed to communicate corridor status and to advise alternate corridor(s).

1A-8. The corridor communications architecture shall allow implementation of national standard protocols.

1A-9. The corridor controllers shall be integrated if installed with fault tolerant optical communications for new construction and new additions to an existing jurisdictional field environment.

1A-10. Where installed, the fiber optic infrastructure along the corridors shall be developed in such a manner as to support formation of the peer-to-peer, backbone communications network.

1A-11. Wireless seamless interconnection shall be utilized where traffic conditions and business interruptions will not allow fiber installation.

1A-12. Corridor controller communications shall be terminated into a standard jurisdictional communications gateway. The gateway shall be an intelligent multiplexer that controls access to the jurisdictional low-speed controller links, complies with NEMA environmental requirements, is fault tolerant, and includes an internal bridge/routing capability.

1A-13. The gateway shall be integrated with the TOC optical communications link, if such a link exists.

1A-14. The gateway shall be terminated within the TOC into a DS-l/Ethernet bridge/router.

1A-15. The TOC information processing and display environment shall be upgraded to accommodate the new field environment.

1A-16. The TOC shall be upgraded with medium hybrid control capability where applicable.

3.1.2.2 Phase 1A Cost Estimate

In order to develop rough order of magnitude cost estimates for this phase, a cursory analysis of the requirements was performed. This analysis involved examining the MAGIC ten priority corridors with respect to the jurisdictions involved, the type of signal system utilized, the length of the segments, current and expected traffic volumes, incident data, the existing and proposed ADOT FMS, and other related data.

A range of the cost estimates for Phase 1A is established by assuming a high-end state corridor and a "bare-bones" corridor. The cost estimates are provided per mile. Tied to the corridor is the associated cost for a high-end state TOC and a "bare-bones" TOC. All estimates are rounded up to the nearest whole thousand.

System Design

For both estimates, a cost for the design of the system will be required.

This design would consists of performing a top-down structured systems design engineering approach to ensure all requirements are properly captured and translated into a system requirements baseline for an integrated system design. This will include coordinating and managing the procurement, implementation, construction, integration, and testing activities of this entire phase. It consists of only the engineering cost estimated at $200K.

High-End State Corridor

The following are the derived requirements for a high-end corridor mile:

- CCTV monitoring shall be performed at one mile intersections.
- Full-motion video shall be used.
- The one mile corridor shall have one mile of fiber installed to reach the next intersection.
- The one mile corridor shall require l/2 mile of trenching and conduit due to existing infrastructure
- The corridor to TOC shall have five miles of fiber installed as an average corridor to TOC link added to the corridor mile cost estimate.
- The corridor to TOC shall require two miles of trenching and conduit for the average corridor to TOC link added to the corridor mile cost estimate.
- The intersection controller shall be upgraded to a 2070-level controller.
- Electronic signs or VMS's shall be provided every two miles, thus the cost of l/2 electronic sign per mile shall be estimated.
- Mid-link surveillance shall be performed using a machine vision sensor and connected to the fiber interconnection.

This task consists of construction, engineering, capital, and operations and maintenance costs required as specified for a high-end state corridor.

- Fiber cost is estimated at $5/ft or $26.4K/mile.
- Trenching and conduit $25/ft or $132K/mile.
- The estimate of $5K for the machine sensor shall be used (For both directions of travel, the cost shall be $1 OK).
- Machine sensor installation costs shall be approximately $5K per site.
- CCTV cameras including PTZ controllers are estimated at $14K per corridor.
- CCTV video codecs shall be installed at $2K/site.
- CCTV camera installation including labor and materials is estimated at $11K per camera.
- The VMS shall be full-matrix and is estimated to be $20K each and includes controller costs.
- VMS construction cost per site is estimated at $10K.
- VMS engineering cost per site is estimated at $7K.
- Operations and Maintenance is 10% of capital cost.

TABLE 3.1.2.2-1
HIGH-END CORRIDOR

Description	Capital cost ($000's)	Engineering ($000's)	Software ($000's)	Construction ($000's)	Annual O&M ($000's)
Corridor fiber	26				3
Corridor trenching and conduit				61	
Corridor optical transceiver	10				1
Corridor to TOC fiber	130				13
Corridor to TOC trenching and conduit				244	
Controller	3	3			1
Machine vision sensor	10			10	1
CCTV cameras/codes	16			11	2
VMS	10	4		5	1
High-End Corridor	185	7		**331**	**22**

High-End TOC Upgrade

- The high-end TOC shall have an ATMS system with monitoring of an estimated 12 CCTV cameras.
- It shall also have a short-haul microwave site as some of its CCTV's shall be using short-haul microwave.
- Operations and maintenance cost shall be estimated at 10% of capital cost.

TABLE 3.1.2.2-2
HIGH-END TOC UPGRADE

Description	Capital Cost ($000's)	Engineering ($000's)	Software ($000's)	Construction ($000's)	Annual O&M ($000's)
ATMS Server	55		65		6
GPS Receiver	2	1			1
Gateway	41				4
Regional hub	50				5
Ethernet LAN/Bridge/Router	8				1
12cclv monitors/code&witcher	31				3
Video wall display system	150				15
Data Manager S/W			175		
Short-haul microwave site	15			4	2
System Integration/Test		45			
High-End TOC upgrade	352	46	240	4	37

Bare-Bones Corridor

The following are the derived requirements for a "bare-bones" corridor mile:

- Controllers shall be upgraded to accomodate standard protocol
- Loop surveillance shall be required with 6 loops per mile.
- Interconnection to loop surveillance shall be required assuming that 75% already exists.
- Fiber optics shall not be required
- Electronic signs and/or VMS shall be provided every five miles, thus the cost of l/5 electronic sign per mile shall be estimated.

This task consists of construction, engineering, capital, and operations and maintenance costs required as specified for a bare-bones corridor.

- 6 loop per miles costs are $3K.

3.1.2.3 Phase 1A Summary Costs

A summary of the Phase 1A costs is provided below using an estimated 186 miles of corridors. Two summarizing the high-end and the bare bones systems are provided.

TABLE 3.1.2.3-1
HIGH-END PHASE 1A COST

Description	Quantity	Capital Cost ($000's)	Extension ($000's)	Engineering ($000's)	Software ($000's)	Construction ($000's)	Annual O&M ($000's)
Corridor fiber	186	26	4,836				558
Corridor trenching and conduit	186					11,346	
Corridor optical transceiver	186	10	1,860				186
Corridor to TOC fiber	186	130	24,180				2418
Corridor to TOC trenching and conduit	186					45,384	
Controller	186	3	558	558			186
Machine vision sensor	186	10	1,860			1,860	186
CCTV cameras/codes	186	16	2,976			2,046	372
VMS	186	10	1,876	744		930	186
ATMS Server	11	55	605		65		66
GPS Receiver	11	2	22	11			11
Gateway	11	41	451				44
Regional hub	11	50	550				55
Ethernet LAN/Bridge/Router	11	8	88				11
12 CCTV monitors/codec/switcher	11	31	341				33
Video wall display system	11	150	1,650				165
Data Manager S/W	11				175		
Short-haul microwave site	11	15	165			44	22
System Integration/Test	11			45			
High-End Phase IA		557	42,018	**1313**	240	61,610	4499

If 20 years of operations and maintenance is assumed, the high-end Phase IA cost would be $196M.

TABLE 3.1.2.3-2
BARE-BONES PHASE 1A COST

Description	Quantity	Capital cost ($000's)	Extension ($000's)	Engineering ($000's)	Software ($000's)	Construction ($000's)	Annual O&M ($000's])
Loops	186	3	558				186
Corridor trenching and twisted wire pair	186					7	
Controller	186	3	558	558			186
VMS	186	4	754	186		372	186
GPS Receiver	11	2	22	11			11
Gateway	11	41	451				44
Ethernet LAN/Bridge/Router	11	8	88				11
System Integration/Test	11			330			
Bare-Bones Phase IA		61	2431	1085		379	624

If 20 years of operations and maintenance is assumed, the bare-bones Phase 1A cost would be $16M

3.13 Phase 1B

This phase will result in the installation of a SONET communications backbone,

3.1.3.1 Phase 1B Requirements

1B-1. The backbone SONET network shall be designed.

lB-2. SONET hub equipment shall be installed.

lB-3. The intelligent gateway shall be interconnected with SONET.

lB-4. The field video codec shall be interconnected with SONET.

lB-5. The SONET hub shall be interconnected with bridge/router and codec receiver equipment.

IB-6 ATM ethernet switch shall be added to support ITS functional calls between centers.

3.1.3.2 Phase 1B Tasks

Phase 1B tasks are presented together in this section.

- An engineering design task shall be required, cost estimated at $200K.
- To support Maricopa County and consistent with a high-end Phase 1 A, 11 Sonet hub communication equipments shall be required with cost estimated at $50K each.
- 11 codecs shall be required with cost estimated at $2K each.
- Fiber is estimated at $25/foot for conduit and installation plus $5/foot for cable, or $30/foot.
- The SONET network is 75 miles in length, doubled for dual-ring redundancy.
- All O&M is l0%/year.

TABLE 3.1.3.2-1
PHASE 1B COST

Description	Capital Cost ($000's)	Engineering ($000's)	Software ($000's)	Construction ($000's)	Annual O&M ($000's)
Design the communication system		200			
12 Sonet Hubs	600				60
12 Codecs	24				3
150 miles Fiber	4,000			19,800	400
12 ATM ethernet switch	12				1
Integration/Test					
Phase 1B Cost	4,636	**200**		19.800	464

If 20 years of operations and maintenance is assumed, the Phase 1 B cost would be $34M

3.1.4 Phase 2

This phase provides a core ATIS capability with each jurisdiction providing corridor conditions data. By reducing or increasing functionality, the costs are expected to decrease or increase, respectively.

3.1.4.1 Phase 2 requirements

2-1. The ATIS shall be designed.

2-2. The ATIS shall consolidate area ATIS reports from jurisdictions and transit.

2.3. The ATIS shall prepare consolidated information on corridor conditions and hazards.

2.4. The ATIS shall provide interface to RDS subsystem of FM radio stations.

2.5. The ATIS shall provide transmission of corridor conditions to in-vehicle route guidance systems.

2.6. The ATIS shall provide interface to other public media for use and distribution to viewers/listeners.

2.7. The ATIS shall provide interface to cellular telephone operations center providing traffic conditions reports.

2.8. The ATIS shall be comparable to that developed for the San Francisco Bay Area, Orange County, CA, and St. Louis areas.

3.2.2 Phase 1B: Communications between TOCs

This phase would begin immediately with the planning and design of the communications backbone. Completion of thii phase is within the 10 year implementation goal. The identification of top priority TOC to TOC links would occur early in the programming process. It is anticipated one or two priority links would be identified for immediate design and implementation. It is projected the high priority link(s) and TOC upgrades could be operational within 18 months. This would coincide with the design, construction, and implementation of the phase 1A high priority corridors. The primary tasks and associated activities for this phase are as follows:

- Pre-Design/Programming (12-24 months)
  - Design concept for communications backbone (coordinate with Phase 1 A)
  - Prioritize communications links (TOC to TOC)
  - Survey proposed backbone layout
  - Inventory TOC hardware and evaluate required upgrades
  - Secure funding sources
  - Develop design, construction, and implementation schedule
  - Establish procedures for data sharing and inter-agency transfer of control
  - Establish necessary inter-governmental agreements

- Design/Specifications (18-36 months)
  - Communications backbone
  - SONET hub
  - SONET-intelligent gateway interconnect
  - SONET-field video interconnect
  - SONET-bridge router and codec receiver interconnect
  - ATM Ethernet

- Construction/Installation (12-24 months)
  - Communications backbone
  - SONET hub
  - SONET-intelligent gateway interconnect
  - SONET-field video interconnect
  - SONET-bridge router and codec receiver interconnect
  - ATM Ethernet

- Implementation (12- 18 months)
  - Equipment programming
  - System testing
  - Test and evaluate procedures for data sharing and inter-agency transfer of control
  - Revise procedures as necessary

3.2.3 Phase 1C: Complete Transition to System Architecture

This phase begins where Phase 1 A ends, both functionally and chronologically. This phase consists of converting the remaining field infrastructure (not addressed in Phase 1A) to the system architecture. The arterial improvements identified in this phase would tend to be more toward the bare-bones type installation described in section 3.1.2.2. Completion of this phase is within the 15 year implementation goal. However, Phase 1C is really a transition toward incorporating ITS technology into the TIP process for all roadway capital improvement projects. As new roadways are constructed or existing roadways reconstructed, the system architecture would be integrated into the project. The technologies to be used would be at a level consistent with the functional characteristics of that roadway. The primary tasks and associated activities for this phase are as follows:

- Pre-Design/Programming (12-24 months)
  - Select and prioritize upgrades
  - Inventory existing equipment
  - Secure funding sources
  - Develop design, construction, and implementation schedule
  - Establish necessary inter-governmental agreements

- Design/Specifications (12-24 months)
  - Controller upgrades
  - Traffic sensors
  - Control to TOC communication links (as necessary)

- Construction/Installation (12-24 months)
  - Controller upgrades
  - Traffic sensors
  - Control to TOC communication links (as necessary)

- Implementation (12-24 months)
  - Develop timing and control strategies
  - Programming
  - System testing
  - Implement timing and control strategies

3.2.4 Phase 2: Expansion of ATIS

This phase would also begin immediately, at some level. In fact, the deployment of ATIS has already begun with the implementation of the FMS. The short term and long term location for the "core" ATIS center should be established immediately, as this will affect the communications requirements developed in Phase 1 B. The completion of this phase is within the 15 year implementation goal. The primary tasks and associated activities for this phase are as follows:

- Pre-Design/Programming (6- 12 months)
  - Establish location for the "core" ATIS center
  - Develop design concept for ATIS system, the information database, and various interfaces to the ATIS
  - Secure funding
  - Develop design, construction, and implementation schedule

- Design/Specifications (9- 18 months)
  - ATIS system
  - kiosks
  - RDS interface

- in-vehicle route guidance interface
- CATV interface
- BBS interface
- telephone interface
- cellular phone interface

- Construction/Installation (6- 12 months)
  - ATIS system
  - kiosks
  - RDS interface
  - in-vehicle route guidance interface
  - CATV interface
  - BBS interface
  - telephone interface
  - cellular phone interface

- Implementation (12- 18 months)
  - Programming
  - System testing
  - System evaluation

3.2.5 Phase 3: Deployment of Additional Technologies

Much like Phase lC, the deployment of additional technologies will be a continual process. The system architecture is flexible enough to accept additional technologies such as electronic fee collection. The deployment of these technologies is part of the long term implementation goal. The primary tasks and associated activities for this phase are as follows:

- Pre-Design/Programming (6- 18 months)
  - Identify candidate locations for electronic fee collection
  - Investigate other opportunities/applications for RF tag technology
  - Develop necessary partnerships for standardization of RF tags

Design/Specifications (12-24 months)
- RF beacons
- Sky Harbor central facility
- Communication links (as necessary)

Construction/Installation (12-24 months)
- RF beacons
- Sky Harbor central facility
- Communication links (as necessary)

Implementation (12-24 months)
- Programming
- System testing
- System evaluation

3.3 Management Structure

The objective of preparing a management structure is to establish a framework for policy, process and action between the public and private jurisdictions involved. By establishing a management structure, the interest and involvement of the coalition created for the development of the Strategic Plan for Early Deployment of ITS technologies in Maricopa County will continue. This interest needs to continue in order that deployment of the technologies can in fact become a reality.

3.3.1 Plan Management - Steering Committee

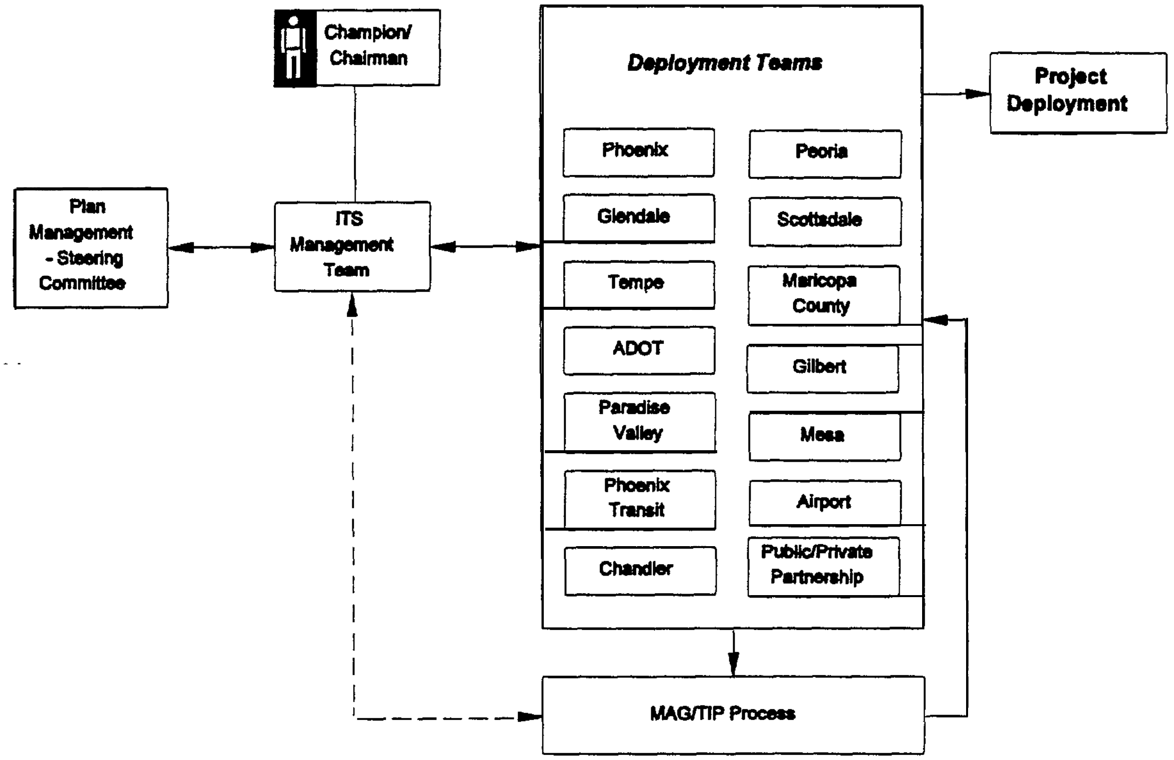
During the development of the strategic plan, the Steering Committee has met regularly each month to receive updates on the status of the plan development and to offer their input as well as to review the deliverables from the study. The interaction of this Steering Committee has brought about a strengthening of the coalition of government and private agencies active in Maricopa County. The steering committee consists of the following individuals representing the indicated agencies,

Jonathan Upchurch	Arizona State University - Chairman of the Steering Committee
Cydney DeModica	Arizona Automobile Association
David Berry	Swift Trucking
Polly Dagras	Motorola
Tammy Flaitz	Maricopa Association of Governments
Alan Hansen	Federal Highway Administration
Sharon Hansen	Maricopa County Department of Transportation
Ty Hofflander	Chandler Department of Transportation
Richard Janke	City of Glendale
Harold Jones	Salt River Pima Maricopa Indian Community
C.E. Kellum	Federal Express
Al Letzkus	Maricopa County Department of Transportation
Mike Nevarez	City of Phoenix, Public Transit Dept.
Dan Powell	Arizona Department of Transportation
Alan Sanderson	City of Mesa, Traffic & Streets
Jim Shea	Arizona Department of Transportation
Diahn Swartz	Pima Association of Governments
Ed VanDerGinst	City of Tempe, Dept. of Transportation
Don Wiltshire	Maricopa County Department of Transportation
Tom Buick	Maricopa County Department of Transportation
Glenn Jonas	Arizona Department of Transportation
Steve Lutman	Maricopa County Department of Transportation
Paul Basha	City of Scottsdale, Traffic Engineering Dept.
Dan Nissen	City of Peoria, Engineering Dept.

supported by the ITS management team, previously discussed. Once the project is on the TIP and is funded, this approval would then go back to the deployment teams for administration of the project and deployment of the particular items.

This recommended management structure utilizes existing organizational structures and existing agencies to the maximum extent possible. The new entity introduced by this management plan is the continuation of the ITS Steering Committee for the management of the plan and the institution of an ITS management team headed by the ITS champion of the Valley. This management team would carry the responsibility of ensuring that the Strategic Plan is carried forward. Figure 3.3-l presents the proposed management structure and project implementation process flow.

Figure 3.3-l
Strategic Plan Deployment Management Structure



CORE INFRASTRUCTURE FEATURES FOR ITS DEPLOYMENT IN METROPOLITAN AREAS

Purpose

This paper presents definitions for a set of seven features which form the "core infrastructure" for deploying Intelligent Transportation System (ITS) traffic management and traveler information services in a metropolitan area. These definitions constitute today's "state-of-the-art" implementation of ITS, which will establish a foundation for deployment of future ITS user services to be provided by both public and private sector entities. By developing and circulating these definitions, the US DOT intends to focus near-term deployment decisions being made in metropolitan areas, and to maximize future opportunities to implement widespread, advanced ITS user services.

Establishment of the core infrastructure features permits optimal operations and management of roadway and transit resources through use of currently-available technologies and strengthened institutional ties. In the near-term, implementation of the core infrastructure features is expected to be lead by the public sector, and development of these capabilities is expected to occur in an evolutionary manner. However, private sector participation is highly encouraged, and appropriate partnership opportunities should be actively sought by State and local implementing agencies. Maturation of the core features in a number of metropolitan areas can be expected to drive private sector development of products and industries to provide future ITS user services.

This paper defines metropolitan area core infrastructure as consisting of seven features. These are:

1. Regional Multimodal Traveler Information Center
2. Traffic Signal Control System(s)
3. Freeway Management System(s)
4. Transit Management System(s)
5. Incident Management Program
6. Electronic Fare Payment System(s)
7. Electronic Toll Collection System(s)

Note that the requirements for a number of ITS user services, such as those relating to commercial vehicle operations and vehicle safety systems, are not included in this document since they do not directly relate to metropolitan ITS user services.

Principles Guiding Definitions

In defining these core infrastructure features, the following principles were followed:

- Deployment of the feature(s) will enable meaningful implementation of metropolitan-area ITS user services and facilitate deployment of many other ITS user services.

- Each feature could be deployed independently of the others, but concurrent implementation would significantly increase overall benefits and/or decrease incremental costs.

- The feature(s) can be readily deployed in the near term using "state-of-the-art" concepts and technologies (versus existing "state-of-the-practice"), and typically would be eligible for Federal-aid funding.

- Varying technologies, from “low-tech” to “high-tech,” can be used to deploy/implement each feature.

- The definitions should account for different institutional environments, varying spatial/geographic relationships among centers of activity (i.e., as with CBD / ring city / suburb relationship), and recognize that system(s) will evolve over time to provide for greater benefits/lower costs.

- Private sector participation in delivering ITS user services will be encouraged to the maximum extent possible, particularly in the collection and dissemination of traveler information. The private sector is also encouraged to participate in development of the core features.

Key Considerations for Deployment of the Core Infrastructure

Based on analysis of the unique needs in a specific area, metropolitan regions usually will pursue implementation of some combination of the core features, eventually leading to a comprehensive ITS. This expected parallel deployment of features is supported to a large degree by common physical (hardware/software) components and institutional relationships which contribute to successful implementation of more than one core feature.

These key fundamentals include:

- Capability to distribute multimodal traveler information to the general traveling public

- Surveillance and detection capability; resulting in current, comprehensive, and accurate traffic and transit system performance information

- Infrastructure-based communications systems linking field equipment with central software/database systems

- Communications (routine information sharing) among jurisdictions, between traffic and transit agencies, and between the public and private sectors; without necessarily relinquishing control responsibility (i.e., “share information but not control”) -This may entail formal interagency agreements for incident response and information sharing

- Information sharing/coordination with emergency medical services, hazardous materials programs, and other appropriate participants

- Proactive management of roadway and transit resources to achieve metropolitan transportation objectives

- Sufficient resources for continuing support of system operations and maintenance needs, including personnel and training requirements

Several of the above points highlight coordination among jurisdictions and agencies within a metropolitan area. The typical metropolitan area transportation system is managed by a diverse set of State and local-level entities, and movement toward implementation of core infrastructure features will occur at different institutional rates. While it is important for individual institutions/jurisdictions to analyze deployment initiatives to meet their specific needs, many advanced ITS services require wide-scale coordination across jurisdictional boundaries. Where these area- wide approaches are envisioned, enhanced communication and coordination of project development concepts, system architectures, interface standards, design/construction schedules, and operations/maintenance responsibilities and resources is crucial.

In addition to metropolitan-specific deployment, these core infrastructure features can form the basis for further deployment of related ITS user services in the national transportation network. This growth may be focussed especially on major intercity arterials which are part of the National Highway System. Through appropriate coordination in program development, the core infrastructure features can support an integrated approach to ITS services such as commercial vehicle systems deployments in major truck network routes, electronic toll and traffic management systems beyond urban areas, and various services along suburban/rural corridors. National compatibility efforts, including application of the emerging national ITS system architecture, will preserve the capability for future expansion, innovation, and advancement of the ITS program.

Definitions of ITS Core Infrastructure Features

1. Regional Multimodal Traveler Information Center

The metropolitan area has a repository of current, comprehensive, and accurate roadway and transit performance data. Potential customers and information providers include individuals, business travelers, private sector firms for which transportation service is critical to success, value-added resellers of the information, and public sector entities responsible for transportation system operation and/or safety. Sufficient data is received to provide for ITS user services such as pre- trip and en-route traveler information, such that informed choices regarding mode, route, and time-of-travel can be made by customers.

This repository, either a single physical facility or an inter-connected set of facilities, directly receives roadway and transit system surveillance and detection information from a variety of sources provided by both the public and private sector entities. To a large degree, these sources (and recipients) of information are the other core infrastructure features. The RMTIC has the capability to combine data from varying sources, package the data in various formats, and provide the information to a variety of distribution channels, including voice or computer services, radio broadcasts, kiosks, etc.

Among the core infrastructure features, the RMTIC is the key feature which provides a bridge between the general public and the transportation system managers. Through linking data from the other features into a comprehensive regional information system, deployment of these Centers will exemplify movement towards advanced ITS user services. Since these RMTIC's do not currently exist and need to be created in most metropolitan areas, compatibility with the emerging ITS system architecture is essential to assure national interoperability and compatibility.

2. Traffic Signal Control System(s)

Signal control system(s) have the capability to adjust the amount of green time for each street and coordinate operation between each signal to maximize the person and vehicular throughput and minimize delay through appropriate response to changes in demand patterns. At a minimum, these coordinated system(s) will provide for a selection of "time-of-day" signal timing patterns which optimize operations along major arterial routes and throughout signal networks. The capability to adjust the traffic signal timing may include computer-generated timing plans and/or manual operation by a skilled and knowledgeable operator. The hardware/software system(s) are designed to be upgraded in capability as required for future operations with an “open architecture” which enables relatively inexpensive and efficient installation of improved products, and potential coordinated operations with adjacent freeway and arterial systems.

The various jurisdictional systems are capable of electronically sharing traffic flow data with the signal systems of adjoining jurisdictions in order to provide metropolitan-wide signal coordination.

3. Freeway Management System(s)

The freeway traffic managers in a metropolitan area have the capability to monitor traffic conditions on the freeway system; identify recurring and non-recurring flow impediments; implement appropriate control and management strategies (such as ramp metering and/or lane control); and provide critical information to travelers through infrastructure-based dissemination methods, such as variable message signs and highway advisory radio.

The freeway management system(s) includes a Freeway Management Center (or multiple centers where responsibility for the freeway system is shared by more than one jurisdiction) and information links to the multimodal traveler information center and other management and control systems in the metropolitan area. These capabilities can encompass and/or expand to provide for coordination of response to emergency and special-event situations. Examples of proactive management include regular analysis and updating of control strategies, and provision of adequate operations and maintenance resources to support the system’s operational objectives.

4. Transit Management System(s)

The transit system(s) in the metropolitan area have implemented fleet management system(s), including hardware/so&are components on buses and in dispatching centers, software, available radio communications spectrum, operator training, and maintenance. Depending upon needs, the fleet management system(s) would utilize automatic vehicle location, include advanced voice and data communications, automatic passenger counting, driver information (voice and visual), vehicle diagnostics, linkage to geographic information systems, and computer-aided dispatching,

The system provides reliable bus position information to the dispatcher. The dispatcher or a central computer compares the actual location with the scheduled location, enabling positive action to improve schedule adherence and expanded information for transmission to the RMTIC and for direct customer information. In addition, on-board sensors automatically monitor data such as vehicle passenger loading, fare collection, drive-line operating conditions, etc.; providing for real-time management response. In the event of an on-board emergency, the dispatcher can inform the police of the emergency situation and direct them to the vehicle’s exact location.

5. Incident Management Program

The metropolitan area has an organized and functioning system for quickly identifying and removing incidents that occur on area freeways and major arterials. The roadway is cleared and flow restored as rapidly as possible, minimizing frustration and delay to the traveling public while at the same time meeting the requirements and responsibilities of the agencies and individuals involved.

The various jurisdictions and agencies responsible for operations and enforcement in the metropolitan area have worked together to develop a policy and operations agreement which defines specific responsibilities for all features of incident management, including detection, verification, response, clearance, scene management, and traffic management and information. This multi-jurisdictional operating agreement ensures routine cooperation, coordination and communication among all agencies; including enforcement, fire, ambulance, highway traffic control and maintenance, environmental and other public agencies. in addition, private sector participants such as the towing and recovery industry may be involved in clearance.

6. Electronic Fare Payment System(s)

An electronic payment system is in operation within the metropolitan area for transit fares. The system(s) include hardware and software for roadside, in-vehicle, and in-station use; and passenger/driver payment cards, possibly with software, financial and card accounting system(s). Electronic fare collection eliminates the need for customers to provide exact change and facilitates the potential creation of a single fare medium for all public transportation services.

The system(s) could include both debit and credit capability; although stored-value capability is a requirement, and cash would also be accepted. Where appropriate, the system(s) would facilitate the participation of employers in transit benefit programs where employers pay for their employees transit accounts which are debited only for work trips.

7. Electronic Toll Collection System(s)

To provide direction and assistance to metropolitan areas engaged in advancing these capabilities, a series of candidate capabilities regarding progress in deploying these core features can be developed. Each of the above definitions contains statements of “required capability” for the core feature, which can be used to generate this type of survey. With appropriate analysis and evaluation expertise, movement towards these capabilities in metropolitan areas can be measured. Through uniformity of this approach, a nationwide view of deployment progress can be developed.

To aid in this survey of core infrastructure deployment, specific measures can be defined to characterize the metropolitan area itself and to gauge progress in implementing the core features. Following are an initial, draft set of selected features which could be used for this purpose:

Urban Area Definition

- Geographic area
- Population: “permanent” and visitors
- Air quality / weather indicators
- Jurisdictions which operate freeways
- Total freeway length
- Total freeway length operating at LOS “D” or worse for over 1 hr./day
- Total toll facility length
- Jurisdictions which operate traffic signals / Number of signals
- Transit agencies / Number of buses; rail systems
- Other ---

Regional Multimodal Traveler Information Center

- Does one exist; single facility or multiple, linked facilities
- Jurisdictions/agencies contributing information
- Dial-up information service
- Other information distribution means
- Areawide traffic info broadcast [e.g. FM subcarrier]
- Private sector firms selling traffic info services
- Operations / maintenance / management personnel
- Other ---

Traffic Signal Control System(s)

- Jurisdictions with signal systems
- Intersections w/ microprocessor controllers
- Signals interconnected with at least one other signal
- Signals centrally controlled
- Signals under 1 st generation control
- Signals under 1.5 GC
- Signals under 2nd GC
- Loop and other electronic detectors
- CCTV cameras
- CCTV cameras with VIDS
- Arterial CMS
- Arterial HAR stations
- Method and frequency of timing plan updates

- Preemption for emergency vehicles
- Signal priority system for transit/other vehicles
- Operations / maintenance / management personnel
- Other ---

Freeway Management System(s)

- Jurisdictions with freeway management systems
- Total length under electronic surveillance
- Total length with lane use control
- Metered ramps
- Loop and other electronic detectors
- CCTV cameras
- CCTV cameras with VIDS
- CMS
- WIM / Inspection Sites
- HAR stations
- Callboxes
- Operations / maintenance / management personnel; facility(ies) description
- Coordination / communication with emergency management entities
- Other ---

Transit Management System(s)

- Transit agencies with fleet management systems; facility(ies) description
- Buses per transit agency
- Buses under fleet management control
- Buses with AVL capability
- Buses with 2-way voice / data communications
- Automated passenger info./electronic schedule systems
- On-board displays - visual or aural
- Station / bus-stop real-time information
- Paratransit / emergency operations applications
- Other --

Incident Management Program

- Incident management programs/policies/operations guidelines
- Service patrols
- Cellular phone # to report incidents
- Typical number of incident calls / responses; per year
- Accident investigation sites
- Average response, verification, and clearance time
- Other ---

Electronic Fare Payment System(s)

- Transit agencies with electronic payment of fares
- Buses equipped with electronic payment systems
- Types of payment cards

- Other ---

Electronic Toll Collection System(s)

- Existing toll authorities / mileage
- Toll authorities with ETC
- Electronic toll collection coverage
- Tags in circulation/subscribers
- Other ---

For more information contact: ***Office of Traffic Management and ITS Applications***

ATM	Asynchronous Transfer Mode. A multiplexed information transfer method in which the information is organized into a fixed length (53 octet) "cells" and transmitted according to each user's instantaneous need. Each cell contains a 5-octet header whose primary purpose is to identify cells belonging to the same "virtual channel".
AutoScope™	A wide area video vehicle detection system
En-Route Driver Information	One of 29 user services, defined by FHWA, part of the Travel and Traffic Management "bundle". En-Route Driver Information provides driver advisories and in-vehicle signing for convenience and safety. Driver advisories are similar to pre-trip planning information, but they are provided once travel begins. Driver advisories convey real-time information about traffic conditions, incidents, construction, transit schedules, and weather conditions to drivers of personal, commercial, and public transit vehicles. This information allows a driver to either select the best route, or shift to another mode in mid-trip if desired. In-vehicle signing, the second component of en-route driver information, provides the same types of information found on physical road signs today, directly in the vehicle. The service could be extended to include warnings of road conditions and safe speeds for specific types of vehicles, such as autos, buses, and large trucks, as well as for drivers of all types of vehicles. This service might be especially useful to elderly drivers, in rural areas with large numbers of tourists, or in areas with unusual or hazardous roadway conditions. (from ***National IVHS Program Plan)***
FHWA User Services	Twenty nine inter-related user services defined by FHWA as part of the national ITS program planning process. User services are defined to meet the safety, mobility, environmental and other transportation-related needs of specified user or group of users.
FMS	Freeway Management System. ***A freeway management system is mix of electronic equipment and human***

operatingprocedures that work together to help reduce traffic congestion, increase safety, and keep things running as smoothly as possible. It helps the freeway work well by monitoring the amount of traffic, by identifying 'incidents" (accidents, stalled vehicles, or any other delay-causing problem) quickly, so they can be removed from the freeway, by letting motorists know in advance about incidents, and by advising them how to avoid the congestion. (from ADOT FMS brochure, Phoenix, Arizona).

Fault Tolerant

Fault tolerance is the ability of a system to perform fault management and continue operating in the event of system failure. Fault management - one of five categories of network management defined by the International Standards Organization (ISO). Detects, isolates, and corrects network faults.

GPS Time Base

GPS - Navstar Global Positioning System, used by networks for synchronization. GPS Time Base allows 3

Interoperability	The ability of heterogenous systems and networks to communicate and cooperate through specified standards.
ISTEA	Intermodal Surface Transportation Act, passed by Congress and approved by the President in December of 1991, becoming Public Law 102-240.
MAGIC	MAGIC - In 1993, the Metropolitan Area Governments Information Center (MAGIC) coalition was formed in response to the growing need for a regional approach to traffic management within Maricopa County. MAGIC is a partnership of government agencies comprised of nine municipalities within Maricopa County, the Arizona Department of Transportation, the Regional Public Transportation Authority, and Maricopa County. The objective of this partnership was to improve regional mobility through enhanced multi-jurisdictional coordination and cooperation. The first step toward the realization of this objective was the Advanced Traffic Management System Feasibility Study which was completed in July of 1994.
National ITS Program Plan	(same as National IVHS Program Plan).
National IVHS Program Plan	A publication by US DOT and ITS America (formerly IVHS America). The primary purpose of the National IVHS Program Plan is to identify the kinds of user needs that can be addressed through IVHS technologies, and describe the services that are being developed or can be developed to meet those needs.
PM-IO (get from Lee)	Suspended particles in the air, the maximum dimension of which is IO microns
PathFinder™	Electronic, illuminated signs, providing dynamically changeable direction to drivers. Provides greater viewing distance over typical signs. Signs can be remotely controlled.
Personalized Public Transit	Provides flexibly-routed transit vehicles to offer more convenient customer service. Small publicly or privately-operated vehicles provide on-demand routing to pick up passengers who have requested service and deliver them to their destinations. Route deviation schemes, in which vehicles leave a fixed route for a short distance to pick up or discharge passengers, also enhances service. Vehicles can include small buses,

taxicabs, or other small, shared-ride vehicles. This service can provide almost door-to-door service, expanding transit coverage to lesser populated locations and with greater convenience than conventional fixed-route transit. (from ***National IVHS Program Plan)***

Pre-Trip Traveler Information

Provides information for selecting the best transportation mode, departure time, and route. Pre-trip travel information allows travelers to access a complete range of intermodal transportation information at home, work, and other major sites where trips originate. Real-time information on transit routes, schedules, transfers, fares, and ride matching services are available to encourage the use of alternatives to the single occupancy vehicle. Information needed for long, inter-urban or vacation trips would also be available. Real-time information on accidents, road construction, alternate route, traffic speeds along given routes, parking conditions, event schedules, and weather information is also included. Based on this information, the traveler can select the best route, modes of travel and departure time, or decide not to make the trip at all. (from ***National IVHS Program Plan)***

Public Transportation Management

Automates operations, planning, and management functions of public transit systems. The public transportation management service provides computer analysis of real-time vehicle and facility status to improve transit operations and maintenance. This analysis identities deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure reliable transfer connections for intermodal trips. Information regarding passenger loading, bus running times, and mileage accumulated will help improve service and facilitate administrative reporting. Transit management is enhanced by automatically recording and verifying tasks performed by transit personnel. (from ***National IVHS Program Plan)***

Route Guidance

Provides travelers with simple instructions on how to best reach their destinations. The route guidance service provides a suggested route to reach a specified destination. Early route guidance systems are based on static information about the roadway network or transit schedules. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route guidance service will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route. Directions will generally consist of suggested routing and simple instructions regarding turns or other upcoming required maneuvers. Users of the service will include not only drivers of all types of vehicles, but also non-vehicular travelers, such as pedestrians or bicyclists, who could get specialized route guidance from a hand-held device. (from ***National IVHS Program Plan)***

SmartSonic™	Passive-acoustic traffic detection technology, alternative to inductive loop sensors. Consists of small overhead-mounted detectors.
Smog Dog	A nickname for a remote sensing system used to measure vehicle exhaust emissions in real-time. The system operates on the principle that infrared light beam, positioned approximately 10 inches above the roadway, will be dispersed by the emissions in the exhaust of the vehicle which crosses the beam and the degree of dispersion measured.
SONET	Synchronous Optical "Network. A family of optical transmission channels for speeds from about DS3 (45 Mb/s) to 2.5 Gb/s (2400 Mb/s) today and higher in the future. Provides broadband connectivity for existing networks on a global scale. "SONET is to broadband what Tl is to digital."
Traffic Signal Systems	A system of interconnected traffic signals (signal controllers) whose major objective is to support continuous movement and minimized delay along an arterial or a network of arterials. To accomplish this objective, a traffic signal (control) system provides appropriate timing plans for each intersection.
Traveler Services Information	Provides a business directory, or "yellow pages," of service information. Traveler services information provides quick access to travel-related services and facilities. Examples of information that might be included are the location, operating hours, and availability of food, lodging, parking, auto repair, hospitals, and police facilities. Traveler services information would be available en-route and accessible in the home, office, or other public locations to facilitate trip planning. When fully deployed, this service will connect users and providers interactively for quick

dissemination of needed information. A comprehensive, integrated service could also support financial transactions, such as automatic billing for purchases. (from ***National IVHS Program Plan)***

Wireless Seamless Interconnect

A communications link established using wireless hardware performing without signal degradation and supporting the communications protocol(s) employed over the remaining part of the line.

Communications Glossary. Kimley-Horn and Associates, Inc., 1994

ITS Glossary. Kimley-Horn and Associates, Inc., 1994

Intelligent Transportation Systems (ITS) Projects. U.S. Department of Transportation - Federal Highway Administration, January 1995

ITS Architecture, Evolutionary Deployment Strategy. U.S. Department of Transportation Federal Highway Administration, June 1995

MAGIC Final Report. Maricopa County Department of Transportation, JHK & Associates and Computran Systems Corp., July 1994.

Communications Handbook for Traffic Control Systems. U.S. Department of Transportation Federal Highway Administration, April 1993.