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Lessons from Case Studies of Advanced Transportation and Information Systems

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ABSTRACT

This paper poses two key questions regarding ATMIS implementation:

- how are ATMIS services successfully implemented?
- in what circumstances are ATMIS strategies cost-effective?

The authors attempt to find answers by examining case studies of twelve jurisdictions. The answers should help others judge where and how ATMIS should be implemented.

The first section of the paper identifies the requirements for successful ATMIS implementation and operation based on the case study findings. The second describes a diffusion pattern found in the case studies. The final section concludes that more is known about *how* to implement ATMIS than about *whether* implementation will be cost-effective and suggests devoting more resources to evaluation.

The first requirement for successful ATMIS implementation is a need for improved traffic management. Given this need, there must also be leadership to initiate and organize a project. This leadership is most often found at the staff level. The leaders must have information. Information is obtained from reading, contact with other transportation professionals, and from consultants, who generally participate at some point in the implementation process. Funding is also needed, and many combinations of sources of funding are possible. Given these basic requirements, community support, multi-agency cooperation, and technical resources can be generated.

ATMIS is first implemented in large, congested cities, particularly those with frequent surges of traffic due to sports or entertainment events. Smaller, nearby cities, seeing the success of ATMIS in these cities, subsequently implement ATMIS.

More evaluation of actual ATMIS implementation is needed to provide a basis for determining the circumstances in which ATMIS is likely to be cost-effective.

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BACKGROUND

Most studies of ITS implementation involve either prospective estimation of performance or field operational tests of the feasibility and benefits of a technology. While useful for testing particular components of systems, these studies do not provide the rich information about benefits, costs, and other effects that real-world experience provides. Therefore, we employed case studies of actual ITS implementations to investigate the implementation process and the potential for cost-effective ITS implementation.

There are two important questions related to ITS implementation. First, how are ITS services successfully implemented? Second, but equally important, in what circumstances are particular ITS strategies cost-effective? This is a key question for both potential ITS implementors and developers of ITS services and products--prospective implementors need to know what will be effective in their particular situations, and developers of ITS services and products need to know the size and nature of their market. Our case studies teach us much about how ITS is implemented. However, we learn little about its cost-effectiveness, because there has been very limited published evaluation.

Our focus is on advanced traffic management systems and traveler information services (ATMIS) provided by government agencies, typically city traffic agencies or state highway agencies. ATMIS includes such information services as: changeable message signs, highway advisory radio, broadcast traffic information, TV traveler information channels, telephone and Internet information. It includes such traffic management activities as: centralized traffic surveillance and control of signals and ramp meters (so that timing can be adjusted to match current traffic conditions), incident detection and management, and electronic toll collection.

CASES STUDIED

The set of case studies spans a range of transportation situations from a small, rural/resort county in Northern California, to the city of Los Angeles, to a congested suburb of Washington D.C. It is by no means a random sample, but it includes non-implementors of ITS as well as some of the most-active implementors. It includes most of the ITS services included in the USDOT's Intelligent Transportation Infrastructure.

Agency	Type and Size of Jurisdiction	Traffic Conditions
Los Angeles	City, 3,500,000 population	Very heavy, periodic surges
Orange County Transportation Auth.	Suburban county adjacent to Los Angeles, 2,500,000 population	Very heavy
Caltrans, District 12	Orange County. highways	Very heavy
Anaheim	Orange County city, 270,000 population	Heavy, periodic surges
Santa Ana	Orange County city, 300,000 population	Heavy
Irvine	Orange County city, 110,000 population	Heavy at times
San Francisco	City, 730,000 population	Very heavy
San Jose	City, 800,000 population	Very heavy
Menlo Park	SF Bay area city, 28,000 population	Moderate
Placer County CMA	Rural county, 180,000 population	Light except on I-80 on weekends
Montgomery County	Suburb of Washington DC	Very heavy
Dallas	City, 2,500,000 population	Very heavy

REQUIREMENTS FOR SUCCESSFUL ITS IMPLEMENTATION

We find clear themes regarding successful implementation. These are illustrated in Figure 1, which shows requirements of both primary and secondary importance.

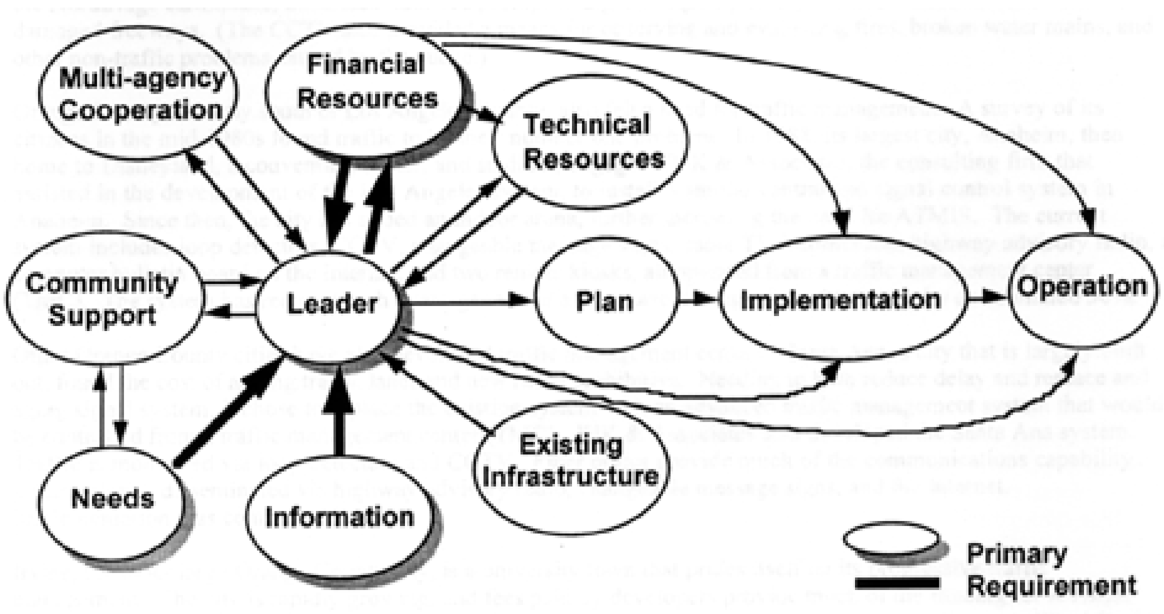

Figure 1 Requirements for Successful ITS Implementation and Operation

The first requirement for successful implementation is a *need*--ITS must meet a *salient*, *perceived* need. In the case of ATMIS, this is generally a need to reduce delay in a situation where congestion is widely perceived as a major problem; ATMIS has little appeal where people perceive little delay. Given a need, there must be someone or some group to *lead* the implementation. Without credible, energetic leadership, implementation does not occur. The leader must have *information* and must seek out *financial resources*. With these basic ingredients, community support, multi-agency cooperation, technical resources, and the existing infrastructure can be brought together into an ITS plan and ultimate implementation and operation.

Need

One of the earliest and most extensive implementations of advanced traffic management systems occurred in the city of Los Angeles. The need was clear. With its large population, Los Angeles had high levels of congestion both on its freeways and city streets. Congestion is particularly severe at activity centers that experience surges of traffic. In 1980, city staff began planning to centrally control signal systems at three such sites: the airport, downtown, and the coliseum. Because of the 1984 Olympics in Los Angeles, the coliseum system was implemented first. It was later extended to the other two sites and beyond. Today, the Advanced Traffic Surveillance and Control system (ATSAC) provides centralized control, performance monitoring, and incident detection for about half of the City's 4200 signals; it is expected that all signals will be in the system by the early 2000s. The current system, developed in-house and implemented in 1993, provides real-time control. It observes demand, redefines critical intersections, and plots traffic volumes. The system includes surveillance via loop detectors and closed circuit television (CCTV), signal trunkline communication via fiber optics, signal optimization software, and real-time remote control of signals. Information is provided to travelers via cable TV, the Internet, and a dial-in telephone system. The signal optimization was initially based on the FHWA's UTCS signal control software. It was customized by a consulting firm, JHK & Associates, to meet the City's needs. Recently, the City has been training its own staff so that it will be less dependent on consultants. The City is working on an expert system to detect incidents and assist in response.

Early evaluations of the ATSAC system found substantial reductions in signal delay. Since the system was implemented, coliseum traffic clears within an hour after a big concert; previously, it took over two hours. The system also detects signal malfunction, which previously had caused unnecessary delay at 24% of the signals. After the Northridge earthquake, the system allowed prompt changes to signal phasing to handle traffic diverted from damaged freeways. (The CCTV also provided a means for observing and evaluating fires, broken water mains, and other non-traffic problems caused by the quake.)

Orange County, directly south of Los Angeles County, also felt a need for traffic management. A survey of its citizens in the mid-1980s found traffic to be their number one problem. In 1988, its largest city, Anaheim, then home to Disneyland, a convention center, and stadium, engaged JHK & Associates, the consulting firm that assisted in the development of the Los Angeles system, to install a similar centralized signal control system in Anaheim. Since then, the city has added an indoor arena, further increasing the need for ATMIS. The current system includes loop detectors, CCTV, changeable message signs, cable TV information, highway advisory radio, a computer bulletin board on the Internet, and two remote kiosks, all operated from a traffic management center (TMC). The system has reduced both event-generated and recurrent congestion, the former by an estimated 30%.

Other Orange County cities have also developed traffic management centers. Santa Ana, a city that is largely built out, found the cost of adding traffic lanes and new roads prohibitive. Needing to both reduce delay and replace and aging signal system, it chose to replace the existing system with an advanced traffic management system that would be controlled from a traffic management center (TMC). JHK & Associates also developed the Santa Ana system. Traffic is monitored via loop detectors and CCTV. Fiber optics provide much of the communications capability. Information is disseminated via highway advisory radio, changeable message signs, and the Internet. Implementation was completed in 1995.

Irvine, the other large Orange County city, is a university town that prides itself on its progressive traffic management. The city is rapidly growing, and fees paid by developers provide much of the funding for ATMIS. As a result the city has been able to install 40 miles of fiber optic cable, a centralized system for controlling all of its signals, and a sophisticated traffic surveillance system (Autoscope), as well as loop detectors and CCTV. JHK & Associates was also one of the developers of the Irvine signal system.

Freeways in Caltrans District 12 in Orange County are the most congested in the state and this District has been very active in establishing a new transportation management center in which the highway patrol, traffic operations, maintenance and a traffic management team are co-located to provide faster, more coordinated response to incidents. Traffic information is provided to travelers via fixed and portable changeable message signs, highway advisory radio, telephone, and the Internet.

Another case of clear need was in San Jose, the largest city in the San Francisco Bay Area, which built a downtown arena and convention center. Concerned about the impact of these facilities on traffic, the City developed a new system to manage its traffic signals. The system, begun in 1991, now includes a surveillance network, remote control of signals, highway advisory radio, and changeable message signs. Before-and-after studies of delay indicate that the system is performing even better than anticipated.

Montgomery County, Maryland, a congested suburb of Washington DC, also has seen a need for ATMIS. Its system includes real-time control of 600 signals, and ultimately 1500 signals, automated incident detection and management, and information gathering to support transportation planning. It utilizes a 200 camera video surveillance system, aerial surveillance, a fiber optic communication system, and a geographical information system. Information is provided to the public via travel advisory radio, automated variable message signs, and cable TV.

Six cities in the Dallas area have instituted ATMIS services. Dallas developed the first system, and as in the Los Angeles area, suburban cities followed. These cities have centralized traffic control and various means of disseminating information.

However, not every congested city or suburb perceives a need for ATMIS. Not far from San Jose, is Menlo Park, a small, affluent suburban city. Not wishing to encourage through traffic on its roads and streets, city staff do not support signal management to reduce delay on these roads and streets. In contrast to San Jose, where the goal of traffic management is service, in Menlo Park, the goal of traffic management appears to be to maintain adequate signalization at minimum cost. The same appears to be true of some of the more affluent Dallas suburbs.

Even in congested San Francisco, where there is a clear need for traffic management, there is not a perceived need for additional traffic surveillance or real-time signal control. The city has 1020 signals in 32 separate signal systems, but because it is geographically compact and traffic is fairly predictable, installation of a system such as in San Jose was not believed to be cost effective. Surveillance and incident reporting is provided by the City's 300 parking control officers, who are on the street dealing with parking violations. ITS service needs are perceived to be related to emergency vehicle management, transit, and parking.

Outside of large metropolitan areas there is substantially less perceived need for traffic management. The cities of Placer County, a rural county in Northern California, do not have traffic problems, and their traffic signals are too far apart to benefit from coordination. Congestion occurs only on I-80 when there is heavy traffic from resorts to the east or bad weather. During heavy snowfall, surveillance is provided by a large force of snowplow operators and the highway patrol. Caltrans provides changeable message signs and highway advisory radio regarding highway conditions.

Leadership

In most of the cases, the implementation was proposed and lead by professional staff who were interested in exploring new ways to reduce congestion. In Los Angeles it was led by people at the head of the transportation agency and a core group of engineers who appreciated the importance of signal control and enjoyed the challenge of utilizing computers systems for this purpose. At the Orange County Transportation Authority, staff became interested in ITS and developed a master plan. At the Caltrans Orange County District, traffic management staff initiated the traffic management center development. In Santa Ana and Irvine implementation was also led by staff. In Montgomery County and Dallas, active traffic staffs also took the lead.

Anaheim and San Jose were different. In Anaheim, implementation was set in motion by a citizen survey that showed traffic to be the number one problem. A subsequent study motivated by the survey determined that a real-time traffic study was needed. The study was conducted by a consultant and implementation was later taken over by city staff. In San Jose, the city council took the lead. Concerned about the traffic impacts of the downtown arena and convention center, it directed the City's traffic operations department to look into establishing a new, high-tech system to manage its traffic signals. At this point, staff took the lead in researching and proposing options for the system.

Information

Information used by the implementors came from a variety of sources. Los Angeles staff benefited from the federally-developed UCTS software for signal control. They were assisted by JHK & Associates, a consulting firm, in adapting the software to the City's system. Since then, the city has been developing its own staff expertise, working directly with equipment suppliers. Later implementors were able to learn from Los Angeles' experience. The Anaheim system is similar to the Los Angeles system in many ways--being UCTS based and developed by the same consulting firm. Irvine, too, followed Los Angeles' lead. Santa Ana, in turn, was influenced by the Anaheim system and used the same consultant. San Jose staff visited the Los Angeles and Anaheim systems and also used the same consultant. The importance of the expertise of the consulting firm JHK & Associates in these implementations can not be overstated.

Information on ITS was also available from reports, studies and meetings. Perhaps the reason why so much ATMIS is staff led, is that staff have information about ITS. They know people in sites where ATMIS has been implemented; they hear about reports and studies; they go to meetings with other traffic professionals.

Funding

There is no standard funding pattern. Los Angeles has typically used federal funds for signal repair and replacement and for development of traffic management systems, and has been successful in acquiring the needed funds, primarily from the FHWA. Anaheim developed its system with funds from a variety of programs and sources, including the FHWA, FTA, Department of Energy, Caltrans and the Orange County Transportation Authority. In San Jose, the City had originally planned to fund the system entirely with local funds, but the availability of ISTEA funds for ITS allowed it to accelerate development of its system. In Dallas, earlier traffic operations investments were bond-funded as part of larger transportation improvement packages. Now such funding is less available and other sources are needed. Irvine has relied heavily on funds from developers to finance its system. Santa Ana's system was funded by state Transportation Systems Management grants.

Community Support, Multi-agency Cooperation, and Technical Resources

The case studies demonstrate that where there was a will--that is, perceived need, leadership, information, and funding -- there was a way-- community support, multi-agency cooperation, and technical resources were forthcoming.

Given that funding has been obtained, community support is not likely to be a problem. In fact, because so much ATMIS is led by staff instead of political leaders, it is likely to go unnoticed by the community until implemented. It does not cause the disruptions that accompany road construction, and does not attract the same kind of opposition. Although ramp meters have been controversial, they have been somewhat insulated from local opposition because they are operated by Caltrans.

Multi-agency cooperation has costs, and expending resources on cooperation does not make sense unless there are clear benefits to be gained. The agencies studied have found creative ways to work together to improve the traffic situation in both cooperating jurisdictions, but the goal was serving their own constituency better, not cooperation for the sake of a regional constituency. For example, Los Angeles has an arrangement in which it can observe and countermand signals in neighboring Culver City when this would expedite traffic. In exchange, Los Angeles staff assist in timing signals for Culver City. Caltrans District 12 is working with Irvine on a system to route traffic through a parallel city street when the freeway is blocked. Several people we interviewed mentioned opportunities for jurisdictions to share expertise and resources. It would be expected that once relationships are formed between staff in various agencies, additional opportunities for mutually beneficial cooperation will be discovered.

Technical problems often hamper implementation. But in dealing with them the state of the art is advanced, as it was in Los Angeles when the FHWA signal control software was implemented. As technology advances, overall system costs should drop, and ITS should become more attractive to cities that do not now consider it cost-effective, such as San Francisco.

Operation

Clearly ATMIS requires staff to provide information and manage traffic. What is often not noted is the need for additional staff to maintain the detection, signal, and communications equipment and traffic management software. San Jose's new traffic management capability required four additional people to maintain communications and detectors and four to keep the signal timing plans current. ATSAC has forty people working on signal operations and timing. It should be noted that the tools to manage traffic--ramp meters, traveler information, traffic surveillance--are more advanced than our knowledge of how to use the tools; there is still much to learn regarding ramp metering strategies, optimum deployment of freeway service patrols, and route guidance to minimize delay.

IMPLEMENTATION PATTERNS

We observe a pattern that we believe is likely to be replicated in other locations. The first implementors, the cities in which ATMIS was implemented earliest and on the largest scale are those with the greatest need and opportunity to manage traffic, Los Angeles, and Dallas.

Other early implementors, San Jose, and Anaheim, followed Los Angeles' lead. Their need arose from surges of traffic from special events--San Jose wanted to manage traffic from its downtown arena and conference center and Anaheim wanted to manage traffic generated by Disneyland, the convention center, the stadium and arena.

Another characteristic of these first implementors is that their systems were not built from scratch. They evolved out of systems already in place. Associated with the existing systems were professional, respected staff.

A second group of implementors see the benefits of ATMIS for neighboring, larger jurisdictions and establish their own ATMIS systems or create links with the larger implementor's system. Santa Ana, Irvine, and the expanded Caltrans District 12 TMC are associated with the Anaheim system, and in a more remote way with the Los Angeles system. San Jose suburbs and Caltrans are working with San Jose to coordinate signals between jurisdictions and develop signal control to facilitate traffic diversion when there are incidents on the freeways. The situation is similar in Dallas. Because this second group of implementors tend to have lesser problems, the benefits of ATMIS are less. However, the costs should also be less because similar systems have already been developed.

An Archetypal Implementation

The pattern observed in our studies may be an archetype for successful early implementation. Localized large generators of predictable pulses of traffic--theme parks, convention centers, stadiums and arenas--have properties that are particularly conducive to early ITS implementation. First, they produce well-defined, localized, and salient traffic congestion. At the same time, the constituency for addressing this congestion tends to be very broad and deep: patrons of events at these facilities, the citizenry (recognizing their personal needs as well as the economic needs of the community), and the business interests directly involved. Support for addressing this need is further amplified if there is an element of special community or national pride, as in the case of an Olympics. A second element of the pattern is that large reductions in delay can be achieved by the application of well established ITS technology. A final, happy corollary is that this type of delay reduction is among the easiest to measure, both experientially by patrons and citizens, and more formally by the operators. In Anaheim, for example, city engineering staff were able to measure the impacts of the new system by timing the emptying of parking lots before and after implementation, and easily and credibly measured dramatic improvements.

Not every community has such fortuitous needs; those that do will find early deployments much easier. Given the already installed infrastructure, they will subsequently be able to expand their services to address other needs that might not in themselves have generated sufficient support to achieve initiation. Similarly, neighboring communities will be motivated to imitate and adopt features of the core system, and to coordinated particular services with it.

CONCLUSIONS

What can be said about the first question posed at the beginning of the paper---how can ATMIS be successfully implemented? We expect that ATMIS will be most extensively implemented in the most congested situations, generally cities in large metropolitan areas. These cities are likely to have the necessary ingredients for successful implementation: need, leadership, information and funding. Where these implementations are successful, implementation in the larger neighboring jurisdictions is likely to follow. The rate of implementation is likely to accelerate due to Operation Time-Saver and will depend on the extent to which funds are available and earmarked for ATMIS.

We have had less success in answering the second question--in what circumstances is a particular ITS strategy cost-effective? The benefits of ATMIS are greatest where congestion is greatest and where there are irregular surges of traffic. Of course, the *incremental* benefits of installing a more advanced signal system depend on the system it replaces; they are greater, the less advanced the replaced system. Benefits are lowest where there is little congestion or little desire to alleviate congestion.

Without credible evaluations, we can not determine all of the circumstances in which the incremental benefits of ATMIS begin to exceed the cost. Ironically, although people are hungry for information about ITS effectiveness, they give low priority to evaluating their own implementation. Benefits, such as total travel time reductions, are difficult to measure, given day to day variations in traffic conditions.   Furthermore, there is a risk that if the benefits are small, the evaluation may make the agency look bad.   Nonetheless, there is a need for such information so that scarce funds are not expended in cost-ineffective ATMIS implementation nor opportunities for cost-effective ATMIS implementation foregone.

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