Metropolitan ITS Deployment Tracking

Extract of Data on Traffic Signals

The ITS Metropolitan Deployment Tracking project is being conducted for the Intelligent Transportation Systems (ITS) Joint Program Office (JPO) to track the level of deployment and integration of the ITS infrastructure. The methodology employed in this effort tracks deployment and integration of the nine components that make up the ITS infrastructure: Freeway Management, Incident Management, Arterial Management, Emergency Management, Transit Management, Electronic Toll Collection, Electronic Fare Payment, Highway Rail Intersections, and Regional Multimodal Traveler Information. Deployment of the ITS infrastructure is tracked through a set of quantitative indicators tied to the major functions of each component. Integration is measured by evaluating the extent of data sharing and operational coordination between agencies. Metropolitan deployment tracking uses surveys targeted at state, county, and local agencies within the metropolitan planning boundary for 78 of the largest metropolitan areas. Data were gathered in this manner in 1997 and these data were updated in 1999 through a new round of surveys. As part of the 1999 data gathering, respondents were asked to estimate levels of deployment for the year 2005.

This report is an extract of traffic signal data gathered through the deployment tracking project. Because the scope of data gathering is limited to the major metropolitan areas, no rural or small urban data are included. The 1999 data are draft only; results have not been reviewed for accuracy and may change. Information from 1997 and 2005 is included in some cases to provide insight into deployment trends. This is not possible in all cases, due to changes in some of the survey questions from 1997 to 1999, or in those cases where 2005 estimates are incomplete.

Characteristics of Traffic Signal Control Agencies

A total of 490 traffic signal control agencies were contacted as part of the 1999 data gathering. Of these, 361 agencies responded and 340 (94%) provided complete responses to questions related to traffic signal control. The surveys included questions about many aspects of arterial traffic management, including technologies for traffic signals, communication, and surveillance as well as interagency interactions.

Traffic signal surveys were targeted at agencies in urban areas with a population greater than 50,000 within the metropolitan planning boundary for each metropolitan area. Table 1 shows the type and number of the traffic signal agencies surveyed and the number of signals they operate. There is wide variation in the total number of signals operated by these agencies, although the average number of signals operated is similar for all three types of agencies.

Agency Type	Number of agencies	Avg. number of signals operated	Min. number of signals operated	Max. number of signals operated
State DOT	53	364	3	1,200
County Agency	105	325	1	11,650
City Agency	182	374	4	10,800
Total	**340**	**352**	**1**	**11,650**

Table 1. Agency types and signals operated

One of the most common technological advances observed is the use of centralized or closed loop control. Centralized control occurs when an agency operates traffic signals from one specific location, as with a master computer in a control room. Closed loop control deals with the ability to communicate with a signal or group of signals, and receive information back from them.

Table 2 includes a breakout of results by agency type. While this technology is widely deployed, agencies do not operate all or even the majority of the traffic signals under centralized or closed loop control. In fact, the majority of state, county, and city agencies operate 50% or less of their total traffic signals under centralized or closed loop control. Only about a fourth of the agencies operate more than 75% of their traffic signals under centralized or closed loop control. There is little variation between the different types of agencies.

Percent of signals operated under centralized or closed loop control	Number of agencies by type (Percentage)		
	State DOT	County Agency	City Agency
100%	6 (11%)	17 (16%)	19 (10%)
75 to 99%	5 (9%)	8 (8%)	32 (18%)
50 to 74%	4 (8%)	20 (19%)	37 (20%)
25 to 49%	8 (15%)	16 (15%)	27 (15%)
1 to 24%	21 (40%)	19 (18%)	29 (16%)
0%	9 (17%)	25 (24%)	38 (21%)
Total (340)	**53 (100%)**	**105 (100%)**	**182 (100%)**

Table 2. Variation of Centralized or Closed Loop by Agency Category

A similar pattern of deployment is shown in Table 3, which includes the variation in the portion of traffic signals that allow preemption for emergency vehicles. Although this type of deployment is also widespread, the total penetration of preemption technology is generally limited to a small portion of the total system of signals. Approximately three fourths of the agencies that provide preemption have less than 25% of their signals equipped with this capability. Once again, there is little variation in the deployment pattern between different agency types. Table 4 shows the variation in the portion of traffic signals that allow priority for transit vehicles. This type of deployment is not as widespread as the emergency preemption, but the market penetration follows a similar pattern. In this case, 84% of the agencies that provide priority have less than 25% of their signals equipped with transit priority.

Percent of signals that allow preemption for Emergency Vehicles	**Number of agencies by type (Percentage)**		
	State DOT	**County Agency**	**City Agency**
100%	1 (2%)	8 (8%)	15 (8%)
75% to 99%	3 (5%)	1 (1%)	10 (6%)
50 to 74%	1 (2%)	9 (9%)	13 (7%)
25 to 49%	4 (8%)	8 (8%)	15 (8%)
1% to 24%	25 (47%)	38 (36%)	81 (45%)
0%	19 (36%)	41 (38%)	48 (26%)
Total (340)	**53 (100%)**	**105 (100%)**	**182 (100%)**

Table 3. Percentage of Signals Allowing Preemption for Emergency Vehicles

Percent of signals that allow priority for Transit Vehicles	**Number of agencies by type (Percentage)**		
	State DOT	**County Agency**	**City Agency**
100%	0 (0%)	2 (2%)	1 (1%)
75% to 99%	0 (0%)	0 (0%)	1 (1%)
50 to 74%	0 (0%)	1 (1%)	1 (1%)
25 to 49%	0 (0%)	1 (1%)	0 (0%)
1% to 24%	3 (6%)	6 (6%)	27 (14%)
0%	50 (94%)	95 (90%)	152 (83%)
Total (340)	**53 (100%)**	**105 (100%)**	**182 (100%)**

Table 4. Percentage of Signals Allowing Priority to Transit Vehicles

Characteristics of Traffic Signal Control Technology

This section includes data about the types of traffic signal technology. Data gathered in 1997, 1999, and estimates of deployment planned for the year 2005 (where available) are included to show trend data.

Arterial Surveillance. The use of electronic surveillance to gather data on traffic conditions shows steady growth from 1997 to 1999 and continued growth is planned for the future. Table 5 show the number of metropolitan areas and the number of agencies that report the existence of real time electronic traffic data collection capabilities on arterials.

Surveillance Technologies	**Number of Metro Areas**			**Number of Agencies**		
	1997	**1999**	**2005**	**1997**	**1999**	**2005**
Existence of real-time electronic traffic data collection capabilities on arterials	47	54	59	87	123	148

Table 5. Arterial Surveillance Technologies

Data collection technologies. The use of traffic signal data collection technologies is projected to increase over the next several years. Figure 2 shows the number of agencies reporting the use of different data collection technologies. Information about the deployment of technologies to provide data on intersection traffic conditions was gathered for 1999, but was not gathered in the earlier 1997 survey. Agencies were also asked to provide estimates of what they were planning to deploy in the year 2005. (See table A.1 in the appendix for detailed data). The use of both loop detectors and video detection cameras is expected to increase but the use of probes on arterials is not.

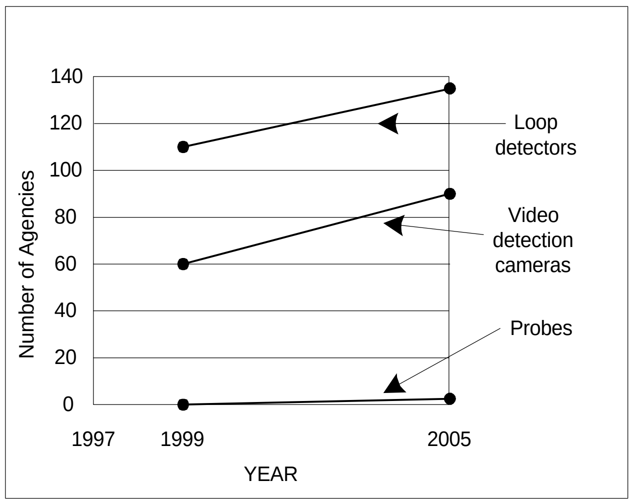

Figure 2 Data Collection Technologies

Traffic signal communication technologies. A variety of technologies are used to communicate with traffic controllers. Figure 3 shows that the use of coaxial cable is leveling off, while fiber optic cable is showing rapid expansion. Of the other technologies, wireless communication is showing the greatest growth. (Deployment information on dial-up modems was not collected in 1997; see table A.2 in the appendix for detailed data).

Controller usage. Figure 4 shows that the use of the NEMA and 170/179 controllers has leveled off, with future growth planned for the 2070. (See table A.3 in the appendix for detailed data).

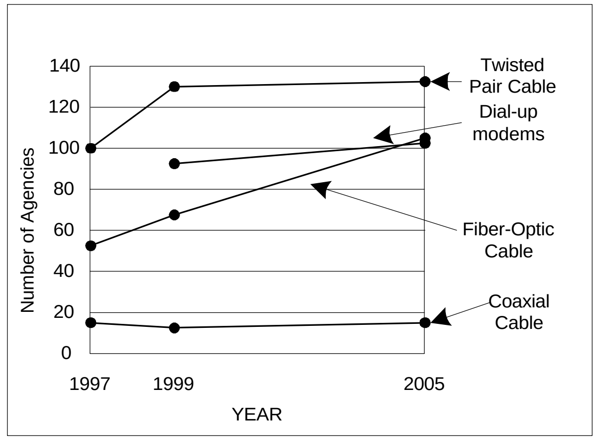

Figure 3 Traffic Signal Communication Technologies

Characteristics of traffic signals. Figure 5 illustrates trends in the characteristics of deployed signals. By the year 2005, the use of closed loop or centralized control will continue to expand to the majority of traffic signal agencies. The use of preemption for emergency vehicles is also expanding and is clearly well accepted. While growing, providing priority for transit vehicles lags behind significantly. (See table A.4 in the appendix for detailed data).

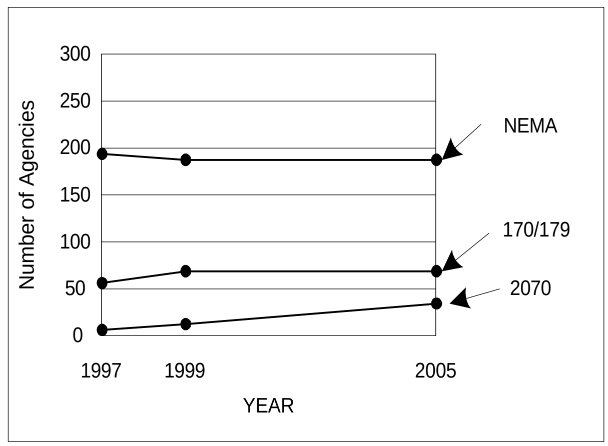

Figure 4 Controller usage

Traffic adaptive control. Traffic adaptive control involves the use of software that continually adjusts signal timings based on real-time changes in traffic patterns. Detectors and sensors are used to collect traffic information in the field to be used in signal timing updates. The two primary examples of traffic adaptive logic are Split, Cycle and Offset Optimizer Technique (SCOOT) and Sydney Coordinated Adaptive Traffic System (SCATS). Of the agencies that responded, three reported using SCOOT and three reported using SCATS. Two agencies reported using their own locally developed traffic adaptive software, such as Caltrans8 Version 4 (C8V4), and Adaptive Traffic Control System (ATCS). Two agencies also reported that they plan to use some type of traffic adaptive software by 2005.

ITS Standards. The survey included questions about the use of ITS standards in general. Thirty eight agencies in twenty five metropolitan areas reported the use of the National Transportation Communications for ITS protocol (NTCIP) standard.

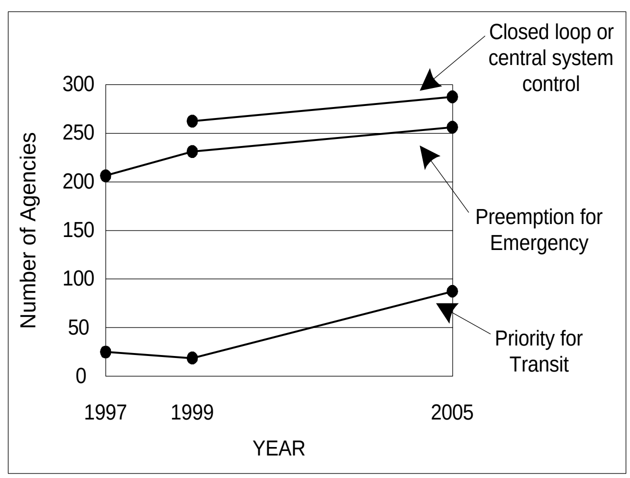

Figure 5 Characteristics of traffic signals

Integration

Traffic signal agencies are integrating with each other and with other agencies at an expanding rate. Table 6 shows the growth of interaction between traffic signal control agencies. The interaction is still mainly a one to one binary relationship, although there is a significant occurrence of multiple agency interactions. Also, it is unclear as to how the agencies share the information, and as to what time period is involved (real-time, weekly, etc.).

Sharing Timing Data. Out of the 361 responding agencies, 205 reported that they share information describing fixed timing plans. Of these 205 agencies, 122 (60%) share this information with only one agency, 40 (20%) share this information with two agencies, 24 (11%) share this information with three agencies, and 19(9%) share this information with four or more agencies.

Coordinating Changes. Out of the 361 responding agencies, 195 reported that they coordinate changes to fixed timing plans. Of these 195 agencies, 124 (63%) coordinate with only one agency, 37 (19%) coordinate with two agencies, 21 (11%) coordinate with three agencies, and 13(7%) coordinate with four or more agencies.

Turning over control. Out of the 361 responding agencies, 84 reported that turn over control of traffic signals during non-peak hours or special events. Of these 84 agencies, 64 (76%) turn over control to one agency, 9 (11%) turn over control to two agencies, 5 (6%) turn over control to three agencies, and 6 (7%) turn over control to four or more agencies.

Arterial Management Intra-agency Integration	**Number of Metro Areas**			**Number of Agencies**		
	1997	**1999**	**2005**	**1997**	**1999**	**2005**
Share information describing fixed timing	50	64	69	137	205	233
Coordinate changes to fixed timing plans	37	60	67	94	195	224
Turn over control of traffic signals during non-peak hours or special events	43	40	44	72	84	95

Table 6. Intra-agency Integration

Integration with other agency types involves sharing information concerning travel conditions on arterials and is shown in Table 7. This is organized by the number of agencies and covers only 1999 and 2005; no data were gathered for 1997.

Arterial management agencies providing arterial travel times, speeds and conditions to:	**Number of Agencies**	
	1999	**2005**
Freeway Management	74	109
Transit Management	38	71
Incident Management	68	109

Table 7. Integration with other agencies

Conclusions

This report constitutes a brief summary of a much larger collection of arterial management data. Several conclusions can be drawn about the state of deployment of traffic signal technology and integration of traffic signal control agencies with other components of the ITS infrastructure.

Traffic signal control agencies are beginning to adopt advanced technology to perform basic arterial management functions, including surveillance and traffic control. The use of electronic surveillance on arterials to gather information on traffic speeds, incidents, and congestion is expanding. One third of the agencies reported the use of this technology in 1999 and future expansion is planned. The loop detector is the predominant surveillance technology employed, with nearly a third of the agencies reporting its use in 1999. The growth of the use of video detection cameras, as an alternate or supplement to loop detectors, is rapidly advancing and is currently in use by one sixth of the agencies. Nearly one fifth of the agencies report the use of fiber optic cable to communicate with signals, with the use of wireless communication making a significant beginning (10% of agencies); however, there is still significant room for additional deployment. While centralized or closed loop control is widely deployed (with over 75% of agencies reporting its use), most agencies operate the majority of their signals under isolated control . In addition, deployment of advanced traffic adaptive systems is limited to a handful of agencies.

Integration, between other traffic signal agencies, as well as with other agency types, is having a significant impact on arterial management operations. Integration with emergency service providers and transit agencies, which provide signal preemption and priority, represents a significant level of institutional and technical coordination. Over 65% of the responding agencies report the capability for signal preemption for emergency vehicles, while 12% support signal priority for transit. The sharing of arterial travel times, speeds, and conditions with freeway management agencies was reported by 20% of the traffic signal agencies, while 11% share data with transit agencies. The coordination between traffic signal agencies is also significant, though still at an early stage. Over 50% of the agencies report that they share timing information and coordinate changes to timing plans with at least one other traffic signal agency. Nearly one fourth of the agencies report that they turn over control of their signals to at least one other agency during non-peak hours or special events. What is particularly interesting about these results is that, in many cases, these interactions involve more than one other agency. More than 20% of responding agencies report sharing information or coordinating timing changes with two or more agencies, while something over 5% of the agencies have arrangements to turn over control with two or more other agencies. This latter type of integration points out the growing importance of interoperability standards, particularly NTCIP, the use of which was reported by 10% of the responding agencies. While these data are significant, there is clearly a long way to go before traffic signal operations are fully integrated within the ITS infrastructure.

Appendix

Data collection technologies	Number of Metro Areas		Number of Agencies	
	1999	2005	1999	2005
Loop detectors	51	57	113	137
Video detection cameras	33	44	60	90
Probe readers reading toll tags	0	3	0	3
Probe readers reading license plates	1	3	1	3

Table A.1 Traffic Signal Data Collection Technologies

	Number of Metro Areas			Number of Agencies		
Communication Technologies	1997	1999	2005	1997	1999	2005
Twisted Pair cable	47	60	61	100	130	133
Coaxial cable	12	11	11	16	13	14
Fiber-optic cable	32	39	53	51	66	107
Wireless	N/A	24	31	N/A	36	49
Dial-up modems	N/A	52	54	N/A	94	102
Leased lines	N/A	20	20	N/A	33	34
Other	N/A	4	4	N/A	4	4

Table A.2 Traffic Signal Communication Technologies

Controllers	Number of Metro Areas			Number of Agencies		
	1997	1999	2005	1997	1999	2005
NEMA	62	58	58	192	173	174
170/179	31	34	35	54	68	69
2070	4	8	24	4	10	33

Table A.3. Controller Usage

Characteristics of traffic signals	Number of Metro Areas			Number of Agencies		
	1997	**1999**	**2005**	**1997**	**1999**	**2005**
Signalized intersections under closed loop or central system control	N/A	71	71	N/A	272	295
Signalized intersections operated that allow signal preemption for emergency vehicles	67	69	70	213	236	256
Signalized intersections operated that allow signal priority for transit vehicles	28	24	41	44	43	87

Table A.4. Characteristics of Traffic Signals