EVALUATION OF A POLICE-IMPLEMENTED
AVM SYSTEM: PHASE I

with

RECOMMENDATIONS FOR OTHER CITIES

A Summary Report

by

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Abstract

This two-part report 1) summarizes the results of an evaluation of an Automatic Vehicle Monitoring (AVM) system, implemented on a trail basis in the St. Louis Metropolitan Police Department; and 2) outlines recommendations for individuals who are interested in pursuing police applications of AVM and other new technologies. The AVM system discussed in Part I is a computer-aided dead-reckoning type, which was implemented as a Phase I prototype system in one police district early in 1975. The evaluation methodology employs a three-pronged analysis of the technology, police operations and attitudinal and organizational impact. Attention is focused on operational performance of the Phase I system, its effect on police operations, such as response time, officer safety, voice-band congestion and command and control, and the effect on attitudes of the police personnel involved in the Phase I program.

The recommendations provided in Part II attempt to relate the potential advantages and disadvantages of AVM to those of other new technologies, such as computer-aided dispatching (CAD) and 911. A process is outlined in which a police department can evaluate its own AVM needs. For those planning to implement an AVM system, certain guidelines are suggested in each of the three important evaluation areas: technological, operational and attitudinal.

For those interested in greater detail of the St. Louis AVM evaluation, a larger document entitled Evaluation of an Implemented AVM System: Phase I is available from the Office of Evaluation,

National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20531.

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The acknowledgments contained in the Phase I Final Report give recognition to many of those who participated in the evaluation effort, and while all of those names will not be repeated here, it is felt that special acknowledgment is due to Chief Eugene Camp, Captain Glenn Pauly (now retired), and Mr. Herbert Bosch of the SLMPD; to Mr. Otto Heinecke, Lt. Paul Herman and Officer Donald Richardson of the St. Louis Commission on Crime; to Mr. Joseph Henson, Mr. Carrol Stevens and Mr. Charles Mathis of the Boeing Company; and to Dr. Richard Linster and Mr. John Spevacek of the Office of Evaluation of the Law Enforcement Assistance Administration. While we wish to thank each of these people for cooperating with PSE in the evaluation effort, PSE takes full responsibility for the contents of this report.

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Part I

A Summary of the Evaluation of an Implemented AVM System

A. Introduction

The potential police uses of automatic vehicle monitoring (AVM) systems were first highlighted by the President's Commission on Law Enforcement and Administration of Justice in 1967.[1] Studies at that time suggested that such systems might achieve cost-effective reductions in police response time. Some hypothesized that AVM would improve apprehension rates and thus serve as a deterrent to crime. Fully eight years after the President's Commission report, the installation of a computer-assisted dead reckoning system[2] by the St. Louis Metropolitan Police Department (SLMPD) represents the first full-scale implementation of an AVM system in a major urban police department.

In our definition, an AVM system provides a police dispatcher with real-time location estimates of each vehicle in a fleet and, through its monitoring function, provides additional vehicle status information (e.g., "in pursuit," "enroute to scene,"

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[1]President's Commission on Law Enforcement and Administration of Justice, Task Force Report, Science and Technology, and The Challenge of Crime in a Free Society, U.S. Government Printing Office, Washington, D.C., 1967.

[2]The AVM system implemented in St. Louis is the Boeing-manufactured FLAIR System. FLAIR is a registered trademark of the Boeing Company, signifying Fleet Location And Information Reporting. It is important to recognize that the issues discussed herein pertain to a specific AVM system, namely the FLAIR System, and, perhaps the most important, to a Phase I prototype system, not an "off-the-shelf" production system.

"driver door open"). An AVL (Automatic Vehicle Location) system provides only location estimates without additional status information. A CAD (Computer-Aided Dispatch) system utilizes a computerized geographic base file to partially automate the call answering, processing and dispatching activities of a police dispatch center. A CAD system may include an AVM or AVL system.

With computer-assisted dead reckoning, vehicle locations are estimated (after their starting positions have been established) by integrating raw distance and heading data transmitted at fixed intervals from the vehicle. The computer assistance occurs in a "map-matching" process which usually constrains a vehicle's estimated position to be on a street and which corrects for accumulated distance errors when the vehicle turns onto another street. This normal mode of tracking is called "closed loop"; a vehicle estimated to be driving on other than a mapped street will be tracked in "open loop" mode, utilizing only the raw data. Occasionally, accumulated errors develop which eventually cause a vehicle to become "lost" (i.e., the computer can no longer match the vehicle's trajectory with possible map routes). When the tracking algorithm recognizes that a vehicle may be lost, the computer causes a "V"[3] to be displayed with the vehicle

[3] When a vehicle travels outside the District 3 boundary (the Phase I test area), is in the vicinity of a magnetic anomaly, or has travelled "too" far in an unmapped "open loop" area, a "W" will appear which notifies the dispatcher to reinitialize the indicated vehicle after a reasonable waiting period.

number, notifying the dispatcher to verify the vehicle's estimated location, and if incorrect, to reinitialize to the proper location.

Vehicle location information is presented to the dispatcher on a computer-driven CRT display map, utilizing various colors, magnification scales, and a dispatcher-controlled cursor for indicating locations of incidents and vehicles. Using this information, the dispatcher can dispatch the closest car(s) to the scene of the incident and perform certain command and control functions heretofor infeasible without real-time vehicle location information. The monitored status of each unit, which is also displayed on the screen, is obtained from voluntarily transmitted canned messages (e.g., "officer-in-trouble," "emergency alarm," "arrived at scene"), utilizing the same car-to-base station digital channel used for transmitting tracking data. In a strict sense, certain of these canned messages transcend the monitoring function and include a number of responses (e.g., "message received") that are normally viewed as part of the radio communication process. Thus, the communicating officer is provided with nearly immediate communication to the dispatcher, regardless of possible congestion in the voice channel. As of early 1976, a Phase I prototype system had been implemented and tested for approximately one year in District 3 of the SLMPD. A Phase II production system, incorporating improvements derived from the

Phase I experience, will be implemented city-wide in late 1976 and early 1977.[4]

B. Evaluation Design

The evaluation of AVM systems and other high technology systems proposed for urban services is especially critical at this time due to the likelihood of their increased use during the coming decades. But any evaluation must go beyond the purely technological features of the system to include the impact of the technology on the operational performance of the urban service and on the attitudes and behavior of the personnel affected by the technology. Building on three prongs--technology, operations, and attitudes--Part I of this report presents a summary of an intensive 18-month evaluation of the Phase I AVM System in District 3 in the SLMPD.

Following the priorities of the SLMPD, the evaluation focused on four AVM objectives.

1) Reduction in response time.
2) Improvement in officer safety.
3) Reduction in voice-band congestion.[5]
4) Enhancement of command and control capabilities.

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[4]See R.W. Lewis and T.W. Leznick, A Report on the Boeing Fleet Location and Information Reporting System, The Boeing Company, Wichita, Kansas (presented at the 10th Annual Carnahan Crime Countermeasures Conference, University of Kentucky, Lexington, KY.) for Boeing's description of FLAIR and the Phase I implementation results.

[5]As pointed out previously, this objective is not strictly AVM related.

In a broader framework, each of these objectives plus others (e.g., better supervision and control of the patrol force) has the potential to improve the productivity of police departments. Considering that typically over 90 percent of a police department's budget is consumed by salaries, fringe benefits and pensions, that each round-the-clock one or two-person patrol car costs $100,000 to $350,000 per year to operate,[6] that many cities are unable to increase budgets of their urban services and that demands for urban services keep rising (sometimes by over 10 percent per year), the need for productively improving systems and procedures is apparent.

Following the three-pronged structure, this part of the report is organized into three sections: technological, operational, and attitudinal analyses. In addition, a concluding section discusses more general issues including benefits and costs of AVM. In considering the results of the evaluation, it is important to remember that the AVM implementation in St. Louis is an "experiment in progress," with Phase II (city-wide) results likely to be quite different from the results of using the early prototype system in District 3. Still, the issues raised in Phase I are

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[6]The annual cost is based on the assumption that five police officers are required to staff a one-person car for three shifts, including weekends, vacations, holidays and sick leave. For a two-person car, ten police officers are required. Depending on salary levels, fringe benefits and overhead rate (which vary considerably) the cost of a one-person car is generally $100,000 and over, and for a two-person car, $200,000 and over.

likely to be important for Phase II. Moreover, many of the St. Louis Phase I experiences are not likely to be unique to a particular city or AVM technology; thus a discussion of these experiences at this time may assist in the consideration and possible implementation of AVM systems and related technologies in other cities, as covered in Part II of this report.

An overall outline of the evaluation plan is presented in Figure 1. Important issues contained under each of the three major headings will be discussed. Full details of the work, including the data collected and analyzed, are contained in the Final Report.[7]

C. Technological Evaluation

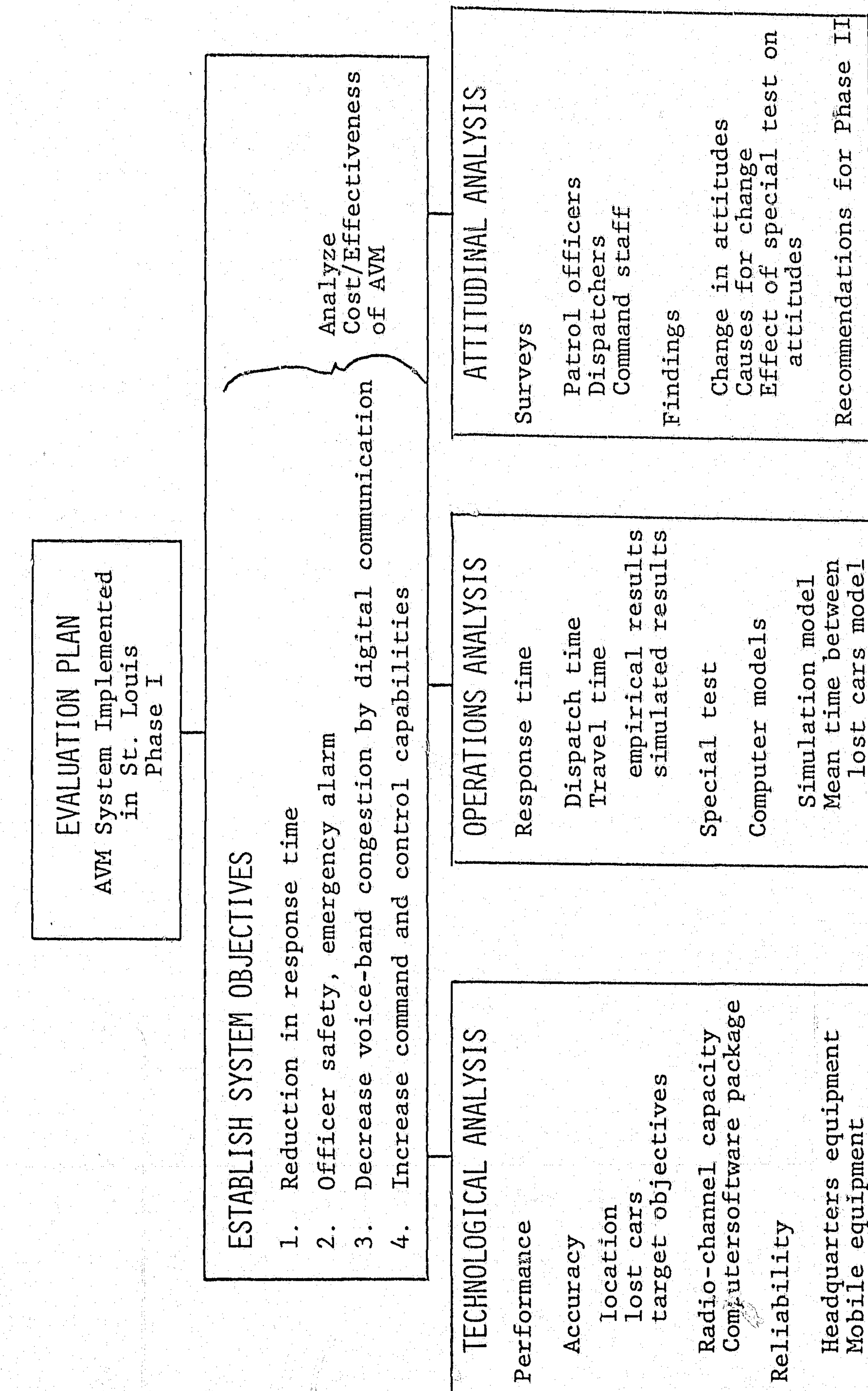
This section reviews Phase I technical performance, with emphasis on identified problems, Phase II corrective actions, and system reliability.

1. System Performance. Considering the complexity of the new technology, the system functioned well. The color display terminal shows the selected map of a part of the city with police vehicles traveling on streets and with each vehicle identified by

[7] R.C. Larson, K.W. Colton, G.C. Larson, M.A. McKnew, "Evaluating an Implemented AVM System - Phase I," Public Systems Evaluation, Inc., Cambridge, Massachusetts, available through the Office of Evaluation, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C., 1976. This is referred to elsewhere in this report as the "Final Report."

Figure 1

Overall Evaluation Plan



number and by class. The display of vehicle status, digital code messages, and the four closest cars to an incident site were readily discerned. Operation of the display terminal was reasonably simple, and most of the better dispatchers integrated the AVM-supplied information into the dispatching process.

The principal hardware operating problem during Phase I was accuracy, particularly as it related to the frequency of lost cars. A major system problem was radio-channel capacity wherein the assigned channel (UHF frequency) accommodated only 97 cars compared to 200 required by the FCC. These problems were largely responsible for two major design changes for Phase II:

- An entirely new radio transmission digital format which provides for the increased number (200) of vehicles per channnel, increased number of bits for distance and heading information, more precise synchronizing signals, satellite stations and other improvements.
- An entirely new software package that increases computer capacity, includes changes to improve open and closed-loop tracking and provides more information on street widths and off-street areas for improved accuracy.

The effect of these changes will be evaluated in Phase II, after city-wide implementation.

a. System Accuracy. Phase I tests showed 95 percent of the vehicle location estimates to be within 625 feet of the true

location, an average location estimation error of 137 feet (upper bound) to 101 feet (lower bound)--depending on the error distribution assumptions, and 80 percent of the estimates to be within 90 feet of the true location.[8] During both regular Phase I operations and a special three-week test period, the system experienced an average of about 11 reinitializations per car per day or about 2.2 hours between losses of a tracked vehicle. The computer assistance in constraining vehicles to be on streets and correcting for accumulated distance errors when a corner is turned is responsible for the exceptional performance for 80 percent of the samples; however, too many of the vehicles escaped the computer hold causing the relatively poor 95 percent confidence level and the large number of lost vehicles.

Errors that cause loss in location accuracy give rise to lost vehicles. A modeling analysis,[9] coupled with empirical tests, indicated that the following factors all contribute to diminished accuracy and smaller values of the mean time between losses (or equivalently, increased values of the number of reinitializations per vehicle per day):

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[8]Based on 713 dispatcher-conducted location checks where actual location of randomly selected cars was compared to the indicated location on the FLAIR display console.

[9]See Chapter V of the Final Report.

Random error - due to tire slippage, irregular driving patterns, speed variations (if viewed as uncorrectable[10]), and mapping errors. For instance, measurements showed that with a calibrated "fifth wheel" errors caused by exaggerated lane switching range from 0.1 percent (five feet per mile) to 0.28 percent (15 feet per mile). Simple geometrical models predicted errors of up to 80 feet due to alternative methods of turning corners and traversing curves (inside versus outside lane). The extent of mapping errors remains an important subject of the Phase II evaluation. Random error also occurs in the heading sensor due to magnetic noise.

Quantization in time, distance and angle - In Phase I, angular and distance resolution was too coarse, being 11.25° and 24 feet respectively. The Phase II system will include two additional bits for each of these variables, yielding resolutions of 2.8° and six feet, respectively. Time quantization was originally two seconds (i.e., location data were transmitted once every two seconds), but that was reduced to one second in Phase I; the Phase II system will have an update interval slightly greater than once per second.

Systematic error - due to temperature, tire wear, and speed (if viewed as correctable). Phase I tests showed that tires increased in diameter with speed, causing errors at 60 mph (compared to 30 mph) of 2 percent (or 106 feet per mile) for a steel belted radial tire. Phase II will incorporate "velocity" correction in the computer algorithm to correct errors from this

[10] That is, variations in speed cause predictable variations in tire circumference. These variations can be "corrected for" in the computer-tracking algorithm.

source. Tires decreased in diameter due to wear, measuring 2 percent (106 feet per mile) for rayon belted and 1.2 percent (63 feet per mile) for steel belted radial. Phase II corrections will provide for odometer recalibrations. Any systematic angular errors are usually corrected in the map-matching process.

Open-loop tracking - Due to crude quantization intervals in Phase I, open-loop driving was a primary cause of lost vehicles. Tests in off-street areas (parking lots, shopping centers, etc.) under open-loop conditions caused a *V* or a *W* to appear from four out of eight areas visited, and required three reinitializations. This indicated poor performance, but the results require further verification because of the small sample size. The finer distance and angular resolutions in Phase II should reduce the extent of this problem.

Missed signals - If the headquarters receiver misses two or more consecutive signals, errors can occur if a turn has occurred during that time. Three or more consecutive missed signals is more serious due to the fact that the digital odometer may recycle, suggesting a much lower travel speed than actual speed. In a test throughout the city involving a total of over 5,000 time-slot transmissions, 2.35 percent of the signals were missed (weak), 0.58 percent were bad data and 0.31 percent were one of two consecutive missed signals. Overall, this is considered good performance except that one area within the city was in the shadow of a hill. A satellite station may be required to provide reliable signal transfer. In Phase II, more historical data are retained in the computer and the algorithm is modified to use these data to reduce the probability of error from these causes.

Susceptibility to subversion - The system is open to acts on the part of patrol officers and/or dispatchers aimed at deliberately reducing system effectiveness. These include deliberate driving near magnetic anomalies, reporting incorrect locations, etc. This will be a major concern of the Phase II evaluation.

While some of the error sources described above appear to be of minor consequence, the cumulative effect of even small errors causes loss of location accuracy. The inclusion of real-time speed monitoring in Phase II (and periodic recalibration of the odometer) are steps in the direction of reducing systematic error. A certain amount of random error will remain--the exact amount to be determined--due to changes in the center-line street mapping technique. Using a model developed for predicting time between losses[11], analysis suggests that reasonably tight tolerances on systematic and random error could reduce to between one and two per day the number of losses (per vehicle) due solely to these types of errors. Of course, additional losses can still occur due to missed signals, open-loop tracking, and system vulnerability.

While it is too early to state required accuracy performance levels, earlier simulation analyses suggest that in a homogeneous

[11] See Chapter X and Appendix A of the Final Report.

[12] R.C. Larson, Urban Police Patrol Analysis, MIT Press, Cambridge, Massachusetts, 1972, Chapter 7.

city with no irregularities in travel paths, virtually all of the possible mean travel time reduction is achievable with ¼-beat length resolution. In District 3 in St. Louis, where the average beat is ½ square mile, the average beat length is $1/\sqrt{2} \approx 0.707$ mile. Thus, ¼-beat length resolution corresponds to $\frac{0.707}{4} \approx 0.177$ mile = 933 feet. However, other considerations give rise to a more stringent resolution requirement. For example, to determine on which side of a barrier (e.g., an expressway) a car is located; to quickly locate an officer in trouble in a high-density urban area; or to direct cars to specific streets during a command and control operation (chases, sealing off an area, etc.) -- accuracy of one-half block or better is desired. In St. Louis, this would indicate an accuracy requirement of approximately 220 feet with 95% confidence, based on the estimated average block length. The FLAIR System has an accuracy requirement that appears even more stringent, in that it must correctly identify each street (including alleys) onto which a vehicle has turned, which, in the case of the short dimension of many rectangular blocks, implies an accuracy requirement of 100-150 feet with 95% confidence, or higher. (If the tracking computer associates a turn with an incorrect street, it will attempt to relocate the vehicle to the correct street, but the risk of the vehicle becoming lost is considered quite high.)

Regarding the frequency of lost vehicles, a level of performance should be achieved substantially better than 11 reinitializations per car per day (as experienced in Phase I). It is difficult to establish a precise target objective of tolerable reinitializations per car per day because workloads, confidence levels and attitudes of those using this system are involved. For this particular AVM technology, the requirement for occasional reinitialization can be rationalized as a trade-off for the feature of having location estimates pinpointed to street center-lines, which facilitates, for example, command and control operations. For this benefit, a "price," perhaps of three to four reinitializations per car per day, may be reasonable.

b. System Reliability. Failures in the base station cause the entire system to be inoperative. During Phase I, the mean time between failure (MTBF) was 38.9 days, the mean time to repair (MTTR) was 1.32 days--resulting in a total down time per year of 12 days. Most of these failures were computer-related. Phase II will have a standby computer, which should greatly improve this performance. However, the transfer from one computer to the other is a manual operation requiring perhaps a half hour to accomplish--and this does not include the time required to initialize the cars in the fleet that have moved during this period and those that have not been self-initialized.[13]

For the AVM mobile equipment, the mean time between failure was 7.7 days per car. The mean time to repair is estimated

[13] During Phase I, a police car could drive to a location directly in front of the District 3 station, transmit a code "22," and be self-initialized to that location without assistance from the dispatcher. In Phase II 22 such self-initialization locations are planned.

at 1.05 hours. (This repair time does not include delays at the repair shop due to backlog of cars requiring servicing.) The most recurrent repair problem was recalibration of the magnetic heading sensor, accounting for 25 percent of all service problems.

The number of repair incidents in Phase I is considered high, but perhaps not unreasonable for a trial system. Reliability was adversely affected by temporary fixes that were applied as problems were uncovered. Also, Phase I service operations were hampered by a lack of service information, test equipment, spare parts, and spare AVM-equipped vehicles.

D. Operations Analysis

Reduction in response time is often heard as one of the primary arguments in favor of an AVM system. Thus, a major focus of the Phase I operational evaluation was directed toward response time. To understand the effects of response time due to AVM, it was necessary to examine the entire police response system, both those aspects which were influenced directly by the AVM system and those which were not.

1. Response Time Evaluation. Response time is considered to be the total time between a citizen's attempt to contact the police and the arrival of police service at the scene. Response time is comprised of several distinct components[14]:

[14] For a more complete discussion of the police emergency response system and the potential role of technology in improving system performance, see The Challenge of Crime in a Free Society, U.S. Government Printing Office, Washington, D.C., 1967 and R.C. Larson, Urban Police Patrol Analysis, MIT Press, Cambridge, Massachusetts, 1972, Chapter 7.

- Time until reporting the incident to the police. This includes the time to detect the incident and to make contact with the police.
- Time for complaint evaluation processing. In St. Louis a citizen's call is transferred from the central operator to a complaint evaluator who either forwards information about the incident to the dispatcher or handles the call in some other manner.
- Dispatch time. This is the time from dispatcher notification of an incident until dispatch of a vehicle.
- Travel time. This is the time from dispatch of the police unit until its arrival at the scene of the incident.

Dispatch time and travel time are both "AVM-related" components of response time, being directly influenced by the AVM system. The approximate mean magnitudes of the key components of response time (for District 3) are shown in Figure 2.[15] We now discuss each of the key components in the response system.

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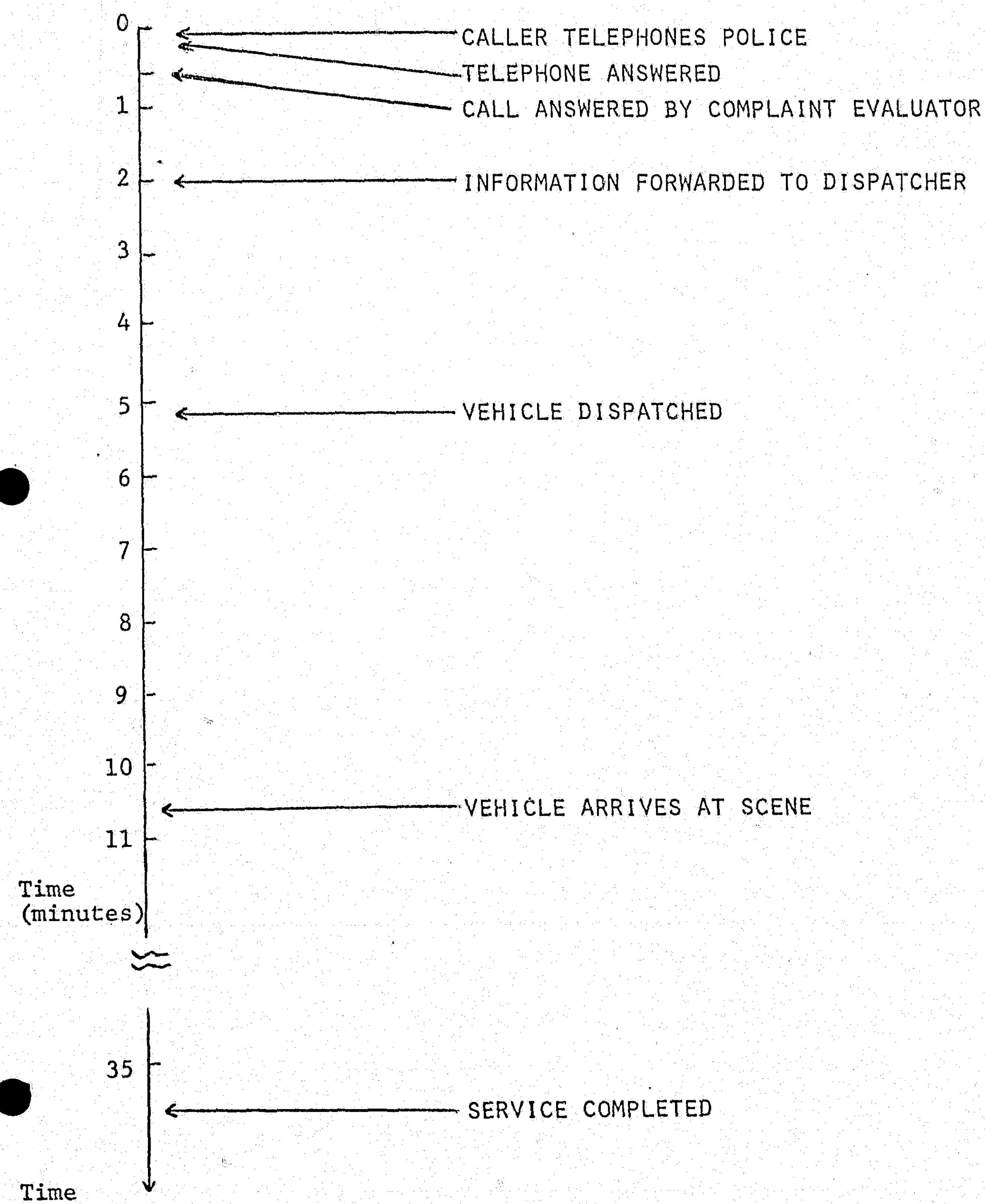
[15] Due to limitations of the incident-type data coding procedure employed by the SLMPD, it was not possible in Phase I to perform a "before and after" analysis of dispatch delays and travel times by priority or urgency of calls. Limited priority-oriented response time information was obtained by an on-site observer, as reported in Chapter VI of the Final Report. The Phase II evaluation will include a more extensive analysis of priority-oriented response times.

Figure 2

POLICE EMERGENCY RESPONSE SYSTEM: MEASURED MEAN RESPONSE TIMES
(St. Louis Metropolitan Police Department, District 3)



a. Telephone Answering Delay. A caller reporting an incident to the police experiences an average of 30 seconds of delay prior to contacting a complaint evaluator. An estimated 20 seconds might be eliminated by implementing two public police telephone numbers in St. Louis--one for emergencies and one for other calls (mostly administrative). Additional early reporting delay reduction could be achieved by making the emergency number the now popular three digit number--911. (Such a change to a 911 system and/or a centrex system is now being considered by the St. Louis MPD.)

b. Complaint Evaluation Processing. About 90 seconds are required for the complaint evaluator to record the caller's information and direct it to a dispatcher; about half or more is spent after the telephone conversation. Probably 25 seconds could be eliminated by procedures and/or systems which remove the practice of recording identical information twice and manually looking up a fraction of addresses. One possibility which requires further evaluation is a CAD (Computer-Aided Dispatch) system.

c. Dispatch Time. Proper operation of the AVM system does not require a significant increase in dispatch time. Mean dispatch time during 1975 (January-November) was 3.62 minutes in District 3, down 1.4 percent from 1974. The comparable figures city-wide (less District 3) are 2.55 minutes, down 8.6 percent

from 1974[16], as shown in Table I. The 1975 District 3 dispatch times were consistently greater than 1974 times during the first half of the year, but starting in July they dropped noticeably below the 1974 figures. The initial rise can be attributed to the time required for the dispatchers to learn the use of the new system. Once the system was mastered, though, dispatch times for District 3 dropped significantly, in fact at a rate faster than the overall city-wide average. Other factors which influenced the city-wide and District 3 reduction in dispatch time include a drop in call-for-service workload--a 12 percent decrease in District 3 and a 10 percent reduction city-wide, and perhaps the dispatchers' awareness of the increased attention being given to this matter due to the presence of on-scene evaluators.

d. Dispatcher Workload. While mean dispatcher times increased for District 3 during the first several months of AVM operation, the decrease in dispatch times over the remaining months indicates that the effect of increase in workload is at least balanced by other factors. The AVM system is estimated to create 5.6 minutes of additional work per hour for the dispatcher--due to reinitializations and cursor positioning on dispatches--that would not occur without AVM. However, some of the time that would have been spent in on-the-air conversations is eliminated by the car-to-dispatcher digital codes. Whether or not dispatcher workload

[16] Dispatch time in District 3 has consistently been longer than in the rest of the city. Probable reasons for this include the heavy workload in District 3 and the resulting queuing of dispatches during peak periods.

Table I

Average Dispatch Delays

(Entries in boxes correspond to months of intensive on-scene evaluation, including stop-watch monitoring, interviewing, and special testing.)

	District 3			City-Wide Less District 3		
	1974	1975	% Change	1974	1975	% Change
	Average Dispatch Delays (in minutes)			Average Dispatch Delays (in minutes)		
JAN	3.22	3.46	+7.4	2.44	1.76	-27.9
FEB	3.02	3.46	+14.6	2.20	1.81	-17.7
MAR	3.25	3.21	-1.2	2.29	1.80	-21.4
APR	2.65	2.93	+10.6	2.19	2.05	-6.4
MAY	2.54	3.66	+44.1	2.12	3.56	+67.9
JUN	3.70	4.38	+18.4	2.93	2.84	-3.1
JUL	5.22	3.62	-30.6	3.41	2.74	-19.6
AUG	4.60	4.06	-11.7	3.85	2.92	-24.2
SEP	4.74	3.81	-19.6	3.52	3.02	-14.2
OCT	3.46	3.34	-0.9	3.03	2.78	-8.2
NOV	3.97	3.77	-5.0	2.75	2.79	+1.4
AVG	3.67	3.62	-1.4	2.79	2.55	-8.6

is in fact increased, dispatchers do perceive an increase. This appears to arise from dispatchers being constantly aware of a location check (*V* or *W*) that may be queued in the status column, thereby yielding anticipated periods of inactivity less often than they would without AVM.

e. Limitation of AVM Dispatch Information. After the dispatcher locates the cursor at an incident site, the computer selects the four closest cars and displays the car numbers on the CRT screen in the order of distance from the incident site. The computer determines the distance by adding the *X* dimension (East-West) to the *Y* dimension (North-South), which gives correct answers when the blocks are laid out in this manner. However, in areas where the axis is rotated to other than North-South and East-West, or where diagonal streets exist, errors result from this method of computation, which--from examples constructed--can exceed one minute in estimated travel time. Also, the computer listing of closest cars does not take into consideration barriers (such as expressways, canals, etc.) or one-way streets. It is therefore necessary that the dispatcher verify the closest car by observing its location on the visual display.

f. Travel Time: Simulated Results. Employing a specially developed simulation model of police patrol and dispatching,[17]

[17] See Chapter VI of the Final Report.

mean travel time was estimated to be reduced by up to 25 percent by switching from pre-AVM dispatching procedures to closest car dispatching. However, a large fraction of this anticipated reduction in travel time is attributable to the relatively inefficient (from the perspective of dispatching the closest car) precinct-oriented dispatch strategy used prior to AVM.[18] Other modeling analyses indicate that about the most travel time reduction that can be expected from AVM is roughly 11 to 15 percent, not 25 percent, when compared to more conventional non-precinct oriented dispatch policies. The potential benefits of AVM, then, depend critically on the dispatching policy to which it is compared.[19]

g. Travel Time: Empirical Results. Mean travel time in District 3 decreased an average of 8.0 percent to 4.9 minutes during 1975 (January-November) compared to the analagous pre-AVM period in 1974. However, mean city-wide travel time decreased

[18] In St. Louis, a precinct is a small collection of contiguous beats, and each district contains two or more precincts. Dispatch preferences are given to precinct vehicles, even if a vehicle in the same district, but another precinct, is closer.

[19] During the Phase II evaluation, the AVM patrol modeling analysis will include a new analytical model, as well as the simulation model. R.C. Larson and E.A. Franck, "Dispatching the Units of Emergency Service Systems Using Automatic Vehicle Location: A Computer-Based Markov Hypercube Model," Report TR-21-76, Innovative Resource Planning Project, Massachusetts Institute of Technology, Cambridge, Massachusetts, April, 1976. Submitted to the Journal of Computers and Operations Research.

7.0 percent to 4.7 minutes during this period (see Table II). Due to under-utilization of AVM during much of 1975, it is difficult to draw strong conclusions from these data. During a specially monitored three-week test, mean travel time in District 3 was down 15 percent (0.89 minutes) in the test district as compared to the 12-month earlier (pre-AVM) levels, but city-wide mean travel times were down 11 percent, suggesting a net 4 percent decrease (approximately 15 seconds) due to AVM. Some of these reductions could have arisen from decreased call-for-service workloads in 1975. Regarding the effect of AVM on average travel times, we must view the results of Phase I as inconclusive. Certainly there is no indication that AVM increases travel time; but the empirical evidence that it decreases is not very strong. Dispatchers' attitudes, perceptions and motivations may have played a key role in measured travel time reduction--both in District 3 and city-wide.

h. Overall Response System Considerations. As shown in Figure 2, mean system response time in District 3 is approximately two minutes (reporting the incident and complaint evaluation) + 3.5 minutes (dispatch time) + 5.0 minutes (travel time) = 10.5 minutes. So a 30-second reduction in mean travel time corresponds to about a 5 percent reduction in overall mean response time. Even if the simulated 25 percent reduction in mean AVM travel time is found to apply during Phase II, this would correspond to 1.25 minutes or 75 seconds, about a 12 percent reduction in overall mean response time. Recalling that about half of the simulated

Table II

Average Travel Times

(Entries in boxes correspond to months of intensive on-scene evaluation, including stop-watch monitoring, interviewing and special testing.)

	District 3			City-Wide Less District 3		
	1974	1975	% Change	1974	1975	% Change
	Average Dispatch Delays (in minutes)			Average Dispatch Delays (in minutes)		
JAN	5.44	5.30	-2.57	5.55	4.83	-12.97
FEB	5.16	4.97	-3.68	4.86	4.62	-4.94
MAR	5.29	4.89	-7.56	4.82	4.60	-4.56
APR	5.18	4.79	-7.53	4.76	4.59	-3.57
MAY	5.37	4.90	-8.75	4.90	4.69	-4.29
JUN	5.32	4.83	-9.21	4.89	4.67	-4.50
JUL	5.46	4.78	**-12.45**	5.05	4.73	**-6.34**
AUG	5.59	4.48	**-13.42**	5.29	4.62	**-12.67**
SEP	5.58	4.74	**-15.05**	5.22	4.71	**-9.77**
OCT	5.31	5.18	-2.45	5.02	4.60	-8.37
NOV	5.18	4.97	-5.41	4.97	4.80	-3.42
AVG	5.35	4.92	-8.00	5.03	4.68	-7.00

25 percent reduction is due to precinct-oriented dispatching, only about 37.5 seconds of the travel time reduction could reasonably be attributed to AVM, corresponding to 6 percent of the total system response time. One of the conclusions from this is that if the SLMPD personnel are interested in average response time improvements they should also concentrate on other aspects of the police response system which are not directly related to AVM. The Phase II implementation will allow adequate sample size and data coding procedures to examine response times as a function of priority or urgency of the call.

i. Cross-Beat Dispatches. Closest-unit dispatching (utilizing AVM) influences patrol performance since it results in a greater amount of cross-beat and cross-district dispatching. In non-AVM dispatching systems, the fraction of dispatches that are interbeat is usually about equal to the average workload of the patrol force--that is, the fraction of time not available for dispatch.[20] With AVM, this fraction is increased, usually markedly for low-to-moderate workload systems. Using the simulation model, this behavior was found to be true for District 3. Such increases in cross-beat dispatches should be of particular concern to police departments that desire to maintain (to the extent feasible) the one-man, one-beat concept. For other departments that desire wider overlapping areas of patrol responsibility, this operational consequence of AVM dispatching should cause little or no problem.

[20] See Chapter 8 of Urban Police Patrol Analysis.

2. Special Three-Week Test. A number of operational and accuracy difficulties developed during the Phase I implementation of the AVM system in District 3. In addition to accuracy difficulties, on-scene evaluation suggested that the dispatchers were not using the AVM system as it was intended to be used during much of Phase I. In one sample, the cursor was used on only about 35 percent of discretionary dispatches and information from the closest car column influenced the dispatch for only 19 percent of dispatches. Wide variability of these figures by dispatchers indicates that certain dispatchers were well-motivated and used the system as intended; others bordered on virtually ignoring the system. Part of the problem was created by an overall decreased interest in AVM due to a lack of a fully AVM-equipped fleet of vehicles in District 3 during Phase I.

In order to examine the operations and influence of the Phase I system under a more favorable set of circumstances, a special test was designed and conducted in District 3 from September 15 to October 5, 1975. The test was needed to study the operation of the system under two important conditions: 1) proper use by dispatchers (a special set of dispatchers was selected) and 2) full coverage of the entire district by AVM-equipped cars (utilizing "spare" AVM vehicles during times of repair). Some of the relevant conclusions are summarized below:

The operation of the system improved significantly. During the test substantial improvement was experienced in the proper use

of the system. Dispatchers utilized the intended components of the system to dispatch the closest car, and patrol officers seemed more satisfied in overall operations. Although no specific surveys were conducted, on-site evaluators (after talking to patrol officers and riding patrol in police vehicles) reported an increase in confidence in the system. As reported earlier, travel time was reduced during the three-week test, but not substantially (when normalized for city-wide reductions). Once again the special test confirmed that if the system is operated properly, there should be no increase in dispatch time.

Trained and motivated dispatchers are essential to the successful use of the system. With effective and motivated dispatchers, an AVM system can increase the general effectiveness of the dispatching process. The ability to dispatch the closest car with such a sophisticated technology not only improves dispatch decisions directly, but it appears to increase the perceived level of professionalism of dispatchers. Also, the way the dispatchers use AVM as an aid to their activities is a major factor in the way officers in the field regard the AVM system, thereby affecting field performance through such activities as voluntary self-reinitializations.

Spare vehicles and maintenance personnel are essential. System performance and user attitudes are very adversely affected by the presence of non-AVM vehicles. Many of the favorable findings of the three-week test are directly attributable to fielding a full contingent of AVM-equipped vehicles at all times.

E. Analysis of Attitudinal and Organizational Impact

The implementation of an AVM system implies more than the routine introduction of a new technology; such an innovation also has important behavioral and organizational consequences. A number of "successes" have been achieved to date regarding the implementation of "routine" technological innovations in police departments, such as establishing real-time computer information systems to provide rapid retrieval of information for the officer in the street. However, when efforts to implement technology have gone beyond routine systems to more non-routine innovations, such as transferring modeling or operations research type technologies or implementing an AVM or CAD system, the process has proven to be far more complex and the success to date has been limited. One of the reasons that such efforts have faltered has been a failure to give sufficient consideration to behavioral and human factors. A number of studies have demonstrated that it is often not technical difficulties which limit long-run implementation, but behavioral and people-oriented factors.[21] Attitudinal and organizational implications therefore comprise one of the primary components of this evaluation.

Attitudinal surveys of both dispatchers and patrol officers in Districts 3 and 5 (the latter being the control district) were conducted, both before and after the implementation of the system.

[21] Robert K. Yin, Karen A. Heald, Mary E. Vogel, Patricia D. Fleischauer, and Bruce C. Vladeck, A Review of Case Studies of Technological Innovations in State and Local Government, The Rand Corporation, R-18070-NSF, February, 1976.

The results of these surveys will first be summarized, and then their implications for the Phase II implementation of FLAIR will be outlined.

1. Summary of Findings. General police officer attitudes toward FLAIR shifted significantly during Phase I. Before using the system, 64.4 percent of the District 3 officers thought FLAIR was a "good idea." After the Phase I implementation only 39.8 percent still felt this way. A number of factors contributed to this change in attitude.

- Most important, a crucial link exists between attitudes and system technical performance. Problems with the accuracy and reliability of the system seem to be the primary cause for the drop in attitudes. In 1974, 44 percent of the District 3 police officers felt that there were equipment and computer problems with the FLAIR System. In 1975 the number perceiving such difficulties had almost doubled to 78 percent (Table III).
- Due to such operational problems, many of the initial expectations of the system were not met. Such unfulfilled expectations led to the disillusionment of some officers and a drop in positive feelings toward the system.
- The effective operation of AVM relies heavily on well motivated and trained dispatchers. Since

Table III

Tabulation of Possible FLAIR Problem Areas

District 3 1974	District 3 1975	Possible Problem Areas	District 5 1974	District 5 1975
44.0%	78.2%	Equipment Problems	43.2%	48.4%
15.1	21.0	Lack of Street Support	28.4	28.1
65.1	27.7	Disciplinary Abuses	56.8	53.1
7.8	16.8	Difficulty in Operating	16.2	12.5
N.A.	24.4	Communications Problems	N.A.	12.5

Table IV

Perceived Importance of Policework

District 3 1974	District 3 1975		District 5 1974	District 5 1975
		Dispatching Nearest Officer		
65.1%	30.5%	Very Important	62.2%	63.5%
26.5	37.3	Fairly Important	29.7	25.4
8.4	32.2	Not Important	8.1	11.1
		Officer Safety		
78.7%	53.4%	Very Important	78.4%	80.6%
15.2	21.2	Fairly Important	10.8	8.1
6.1	25.4	Not Important	10.8	11.3

Table V

Perceived Effects of FLAIR on Departmental Disciplinary Process.

District 3 1974	District 3 1975		District 5 1974	District 5 1975
10.3%	6.0%	Fairer	2.7%	8.3%
31.5	68.4	No Difference	27.4	30.0
58.2	25.6	Less Fair	69.9	61.7

the capabilities and motivations of the Phase I dispatchers were mixed, this uneven quality contributed to the shift in attitudes.

- Attitudes are volatile and a downward trend may be reversible if the Phase II system functions smoothly. In fact, during the special three-week test conducted in September and October of 1975, the careful selection of dispatchers, the availability of a full fleet of AVM-equipped cars, and personal two-way radios all seemed to have a positive influence on the officers in the Third District. Still, once a negative attitude is established, initial impressions are difficult to overcome.

Two other factors were found to be especially important in influencing attitudes toward FLAIR: the level of information about the system and the initial source of information. A pre-implementation training seminar in District 3 seemed instrumental in influencing positive attitudes as compared to District 5, where much of the information about FLAIR was communicated by word of mouth. Even after the attitudes of the officers in District 3 dropped, a strong correlation was found to exist between those officers who were favorable toward FLAIR and those who felt well-informed about the system. Regarding the intial source of information, the opinions of other officers seemed particularly important in influencing and reenforcing feelings toward the new system.

The shift in officer attitudes during Phase I included a shift in the perceived influence of AVM on four areas of police operation.

- Although officer safety remained as the top area of importance to officers, its overall rating of importance dropped significantly after implementation. Whereas eight out of every ten of the officers surveyed in both Districts 3 and 5 before implementation felt that officer safety was a very important goal in the AVM system, after implementation only five out of ten officers in District 3 maintained such feelings. Operational difficulties obviously influenced the confidence of the officers in whether the system would locate them in times of need. (Table IV)
- The perceived importance of AVM in dispatching the nearest officer also dropped significantly in District 3--again showing the influence of technological problems on attitudes.
- The digital communication capability of the system was perceived by both police officers and

dispatchers to be one of the most important aspects of the new system.
- Concern over disciplinary abuses dropped significantly in District 3 after the Phase I implementation. In 1974, 65.1 percent of the officers expected disciplinary abuses to be the major problem, and in 1975 only 27.7 percent saw such abuses as a major problem (Table III). This drop may be attributed to the operational problems since a number of officers felt that the system could not track them adequately. However, the latent fear that remains in the SLMPD on this matter is demonstrated by the fact that even after implementation in District 3, disciplinary abuses still remain as the primary concern in District 5 (Table V).

Responses to surveys indicate that officers feel that FLAIR will have (or has had) little impact on police preventive patrol. However, officers do feel that the AVM system will improve the ability of the department to keep track of where police officers are located, and in turn, according to survey results, this may diminish their flexibility and force their continued movement on patrol. However, it is important to point out that such comments regarding potential impact on police operations are at this stage primarily speculative based only on initial officer perceptions. Further research is required during Phase II in order to evaluate the impact of FLAIR on police operations.

2. Implications for City-Wide Implementation. In previous studies, a number of factors have been identified which contribute to the successful implementation of new technological innovations.[22] Five factors seem especially important to the Phase II city-wide implementation:

a. Link Between Attitudes and Technology Performance. Accuracy and reliability are essential if the new system is to be accepted and made to work over the long run. In order to avoid the rapid decline in attitudes experienced in District 3 during Phase I, the Phase II system should be tested under realistic operational field conditions before it is implemented city-wide--preferably in District 3 because of the previous experience and familiarity with the system in that District. Even though the system receives such a test, it should be realized that problems may still arise when the system is implemented city-wide (such as map errors, magnetic anomalies, questions resulting from inter-district dispatching, etc.). Such difficulties should be

[22] Factors critical to the successful implementation of new technology are discussed in Chapter X of the Final Report. Also see, K.W. Colton, "Computers and the Police: Police Departments and the New Information Technology," Urban Data Service, International City Manager's Association, Washington, D.C., November, 1974. L. Holliday, D. Jaquette, M. Lawless, E. Quade, J. Chaiken, and J. Crabill, Criminal Justice Models: An Overview, Rand Corporation, October, 1975, Rand Report #R-1859-DOJ, Santa Monica, California. R.K. Yin, et al., A Review of Case Studies of Technological Innovations in State and Local Government.

anticipated as a part of implementing a new technological innovation, and in fact, it is better to prepare people in advance for such occurrences.

b. Involvement and Training of Police Personnel. There is a paramount need for effective training and communication concerning FLAIR. However, this means more than just an initial training seminar. As pointed out earlier, feeling informed about the system was one of the most important factors influencing attitudes toward AVM. An "on-going" dialogue is therefore necessary to answer questions and to candidly explain problems that may arise. In order to achieve such communication, the planned Phase II training should be supplemented by periodic visits by SLMPD and/or AVM manufacturer personnel to the "roll calls" at the beginning of each shift.

On the other hand, care should be taken not to "oversell" the system. Evidence indicates that initial expectations were too high in District 3. In introducing the Phase II system it is important to discuss the problems of Phase I in order to establish a realistic but positive set of expectations.

c. Person-Machine Interface. One of the most significant elements in determining success or failure in implementing new technology is developing the proper human/technology interface. The point at which this is especially vital with FLAIR is the link between the dispatcher and the new system. The role of the dispatcher must receive priority attention in the Phase II implementation. A major turnover in dispatchers has been projected for 1976 due to a discontinuance of a cadet program. Capable people must be placed in the new jobs and this may require an upgrading of the dispatcher's job description, qualifications and salary. In addition, procedures for dispatcher-car interactions should be clearly specified, and special training might be provided. For example, dispatchers now do not receive specific training on how to handle such "rare events" as responding to an officer-in-trouble call, handling pursuits, or handling civil disturbances. One approach to rectify this might be training exercises where dispatchers would be able to simulate these kinds of occurrences.

d. Involvement of Top Police Supervisors. Just as it is important to integrate and train police officers concerning the technology innovation, it is essential that top police supervisors be deeply involved in the implementation of the new technology. Experience in other police departments has shown that new technologies are likely to fail without sustained commitment from top management. With FLAIR, the Phase I results have demonstrated that the response time benefits of the system are below initial expectations. Other potential benefits such as the opportunity for improved command and control or better management of resources must therefore be examined to determine the degree to which the benefits may justify the costs. In order to test these areas, though, the deep involvement of the St. Louis command staff is required. For example, a new set of computer-prepared operational reports has been designed for the Phase II FLAIR System. If these reports are to be worthwhile, they should be modified and perfected by the St. Louis command staff so as to provide the best information possible from a management perspective. Further, to truly test the benefits of the system, it may be appropriate to try new command and control or organizational relationships, at least on a temporary basis, such as assigning a high-level command person to the dispatch center in order to supervise command and control situations when they arise.

e. Long-Term Commitment and Continuity of Personnel Over Time. In a recent study[23], it was found that efforts to implement operations research modeling projects in criminal justice agencies are often promoted by a single or small group of advocates. Although such advocates play an important role in spreading innovation, their presence also leaves the innovation vulnerable if a shift in personnel occurs and the advocate leaves the agency or is transferred. In order to assure success of the AVM system in St. Louis, a long-term commitment based on a broad base of support is required. To broaden involvement and develop support for technological innovation, many police departments have established a management users committee of top level command officers to help monitor and oversee change. The St. Louis MPD might consider establishing such a committee.

[23] L. Holliday, et al., Criminal Justice Models: An Overview, Rand Corporation, October, 1975, Rand Report #R-1859-DOJ, Santa Monica, California.

F. System Objectives and Cost Considerations

An important question in evaluating an AVM system is determining whether the objectives of the system have been met and whether the benefits justify the cost. While it is impossible to reach a final conclusion on these issues based solely on the results of the Phase I system, as a means of summarizing our ideas to date it is worthwhile to state our initial conclusions regarding each of the four primary objectives outlined earlier (Figure 3).

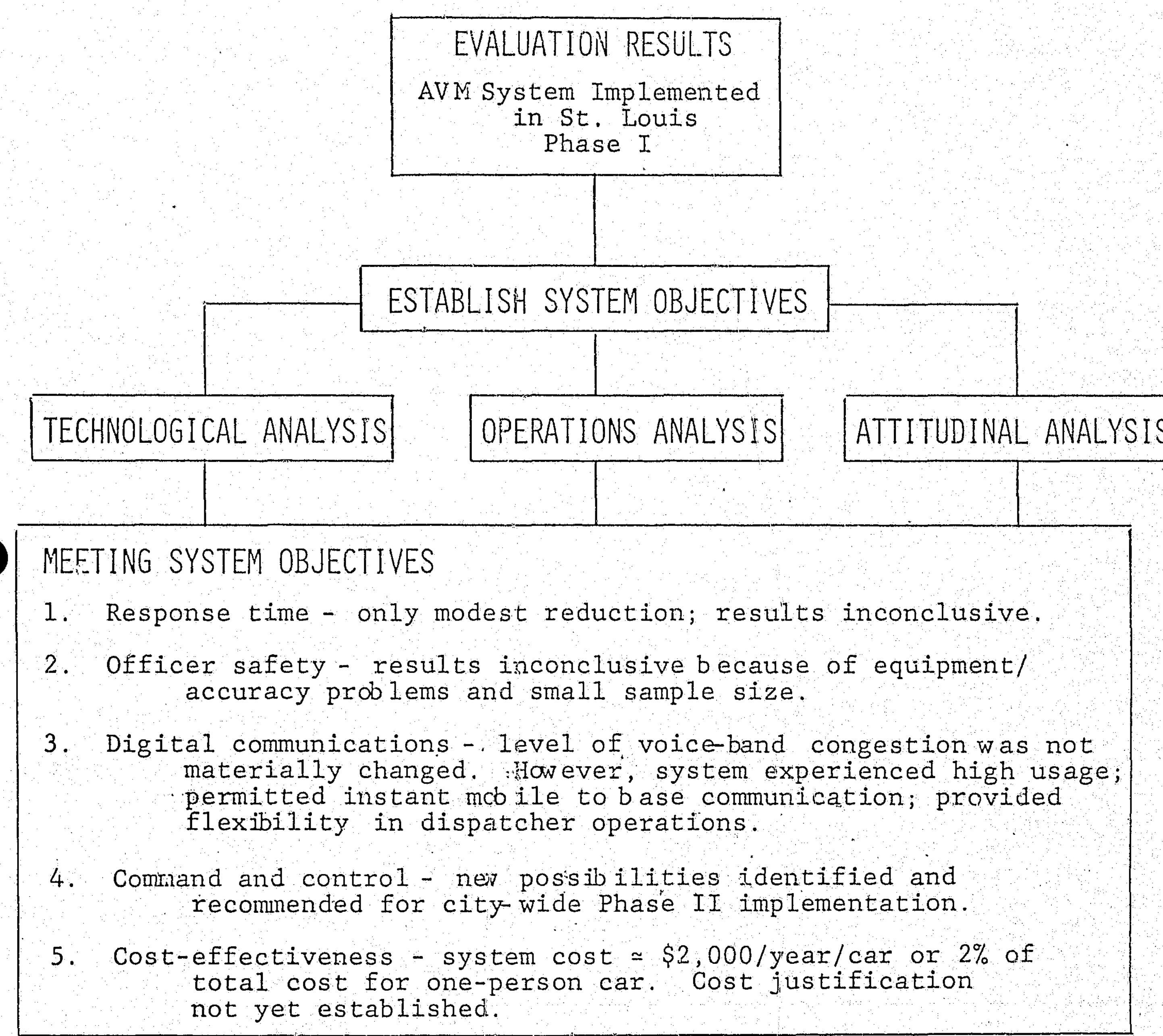
1. Response Time Reduction. Phase I tests do not support the expected reduction in response time. Although this question will be examined closely in Phase II, current findings lack evidence to suggest that savings in travel time due solely to AVM will significantly improve police operations or reduce cost.

2. Officer Safety. When the emergency alarm is activated, the dispatcher is alerted visually and audibly, the location of the activating vehicle is known immediately from the display, and the computer-selected closest cars are identified for quick dispatch. However, the degree of obtaining the officer safety objective has not been established during Phase I, largely for the following reasons:

a. The high rate of lost cars and system location errors has decreased the confidence of patrol officers as to the dispatcher's ability to locate him accurately and consistently.

Figure 3

Summary of Phase I Evaluation Results: Meeting System Objectives



There appears to be a preference of at least some officers to announce their situation and location over the voice radio.

b. The emergency alarm has been improperly used by some officers (e.g., activating the alarm to test whether or not the system is operating) and has been accidentally activated at times causing a "false alarm" condition that decreases the urgency in responding to a real alarm.

c. The number of real alarms has been small, making a proper evaluation difficult due to small sample size.

Improvements in the Phase II system and equipment (to increase accuracy), additional training of the officers and better emergency knob design (to reduce apparent false alarms), and city-wide implementation (to increase the number of incidents) should establish improved conditions for evaluation during Phase II.

3. Reduction in Voice-Band Congestion. Vehicle-to-base station digital communication in this particular AVM system allows transmission of 99 "canned" messages, thereby providing status information and an alternative means of interacting with the dispatcher. An original objective was to decrease voice-band congestion by using this new medium. Tests made by the SLMPD during Phase I showed essentially no change in voice-band occupancy levels. However, other benefits became apparent.

a. High usage of digital communications by the patrol officers involving over 2,000 messages per day or over 100 per day

per car. This amounts to an expansion in the capacity of the communications system compared to what could be accommodated by existing voice channels.

b. The patrol officer can communicate a change in status instantly to the dispatcher; whereas with voice radio only, he might wait for clear channel status which could involve considerable delay or he may not bother to communicate.

c. The dispatcher can organize work tasks better, permitting some digital inquiries to accumulate before acknowledging if other matters have higher priority. Voice radio does not have this flexibility.

d. Digital messages are relatively secure and cannot be intercepted by the commonly available "police" monitor radio.

While not strictly part of an AVM system, both police officers and dispatchers felt that digital communication provided some of the most important benefits of the Phase I system.

4. Command and Control. In our context, command and control pertains to the ability of the dispatcher to deploy (command) vehicles, especially under extraordinary circumstances, and the ability of patrol administrators to control and modify the manner in which patrol operations are conducted.

Utilizing the display, dispatchers had several opportunities during Phase I to incorporate AVM information in with their handling of extraordinary events. For instance, in October, 1975, a chase starting in District 3 resulted in the dispatcher commanding patrol cars by voice radio toward locations for possible interception; after the chase left District 3, however, the effectiveness of the dispatcher was greatly reduced because most of the radio time was spent asking for the locations of the various cars involved. Phase II, being city-wide, will provide more opportunities to evaluate the dispatcher-related command and control benefits of the system.

Few results are available from Phase I regarding the potential of AVM for affecting patrol operations. It was our impression that fewer patrol units volunteered for unnecessary back-up assignments and fewer patrol units appeared to congregate for prolonged visits after AVM than before. Conversely, the AVM-equipped vehicles appeared to be attentive to their assigned duties, whether on assignment or on patrol. This can be observed by viewing the display, and of course the patrol officers are aware of the display.

During Phase II, an attempt will be made to develop measures indicating the extent of improvement of patrol operations. These may include a measure of miles driven per day on preventive patrol as opposed to responding to calls, the number of self-initiated activities, time spent at the District Station, and others.

5. Costs and Related Considerations. The total cost of implementing the Phase II AVM system is estimated at $2,700,000 (including both Phases I and II). However, these expenses must be placed in the context of overall police operations. By extrapolating

probable production costs of this AVM system, we estimate the total system cost to be approximately equal to $9,500 per car (capital investment), or with 10-year life, the annual depreciation about $950 per car per year. The operating/service costs are estimated to exceed this amount, at about $1,000 per car per year. The total of amortized investment cost and operation/maintenance costs over a ten-year period then approaches $2,000 per car per year.

As noted previously, the average cost of fielding a round-the-clock one-person patrol car usually exceeds $100,000 per year or, for a two-person patrol car, $200,000 per year. The total AVM cost at $2,000 per year then represents no more than 2 percent of the cost for a one-person car (or 1 percent for a two-person car). Compared to the one-person car, if it can be shown that AVM will increase the efficiency and effectiveness of the force by x percent (because of better management of the forces), then AVM will provide at least x:2 return on the investment. If x is equal to 10 percent, for example, this would produce an impressive 5:1 return on investment.

It should be realized that more than just monetary factors must be considered when evaluating the advantages and disadvantages of AVM. For example, it is important to examine the implications that AVM might have on police policy and approach. To the extent that AVM stresses rapid response to calls for service and dispatching the closest car, it may limit or conflict with an alternative approach to policing--the "one-person, one beat" approach which gives a patrol officer responsibility for a particular area (such as with team policing). It will most likely be impossible then, to do a definitive review of costs and benefits that will be applicable to all police departments. The costs and benefits for each city will be different and must be reviewed individually depending on their goals and priorities.

Part II

Recommendations for Other Cities

While Part I of this summary report focused on St. Louis-specific results of the Phase I evaluation, Part II attempts to build from the St. Louis experience to present a set of recommendations for potential AVM[24] consumers in the field of law enforcement. Recognizing the "in-progress" nature of the St. Louis evaluation, these recommendations should be viewed as tentative; they may be modified as a result of the Phase II evaluation.

Given the diversity of potential applications of AVM in police operations and given that each city is likely to apply its own unique value weight to each application, it is important that each city analyze its own situation with respect to AVM. A focus of this part of the report is the process by which such an analysis can occur. This ranges from the activity of goal setting, to data collection, to mathematical modeling, to the setting of performance specifications, etc. After outlining the process of analyzing the local situation, critical factors of concern--all derived from our St. Louis experience and related work in the field of law enforcement--are discussed within the

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[24] Part I described the evaluation results of a specific computer-assisted dead-reckoning type AVM system. Part II's reference to AVM includes the broad field of available systems--and not any specific system, unless so mentioned.

three-pronged evaluation framework: operations, technology and attitudes. Part II concludes with a discussion of long-term commitment to AVM and related technologies.

A. Analysis of Local Situation

Each city that is likely to consider the purchase of an AVM system is unique in some way. Each can be described in aggregate terms such as the area of the city, its street mileage, its population density, its annual volume of police calls for service, its total number of sworn personnel, its total number of radio-dispatched vehicles, etc. Other qualities of the city are likely to affect the technical performance of certain types of AVM systems; these include the density and configuration of skyscrapers, the statistical properties of the street layout (including average block length and barriers to travel), the number of patrol vehicles per square mile in various parts of the city, magnetic anomalies, the "hilliness" of a region, etc. Still other qualities of the city's police department itself are apt to affect the operational effectiveness of an AVM system. These include attitudinal and professional factors associated with the personnel. Such factors stem from a department's history of professionalism and willingness to try innovations. They are related to such measures as the percent of personnel with some college education, the percent of civilians in the department, the median age of personnel, the salary level, etc. They are also related to such intangibles as the attitudes

of the chief and his associates and the department's ties to city hall (and the extent to which the department is a part of the city's political structure). The operational effectiveness of an AVM system also depends on the department's dispatch and resource allocation policies. For instance, a department without sufficient patrol manpower to handle the current volume of calls for service is not likely to experience significant reductions in travel time from an AVM system.

Because of these concerns, each city's situation with respect to AVM is unique. The operational benefits and the technical performance of an AVM system in each city will depend to some extent on conditions in that city. So, before purchasing an AVM system, administrators in a city should carefully analyze their own situation in an attempt to assess the likely benefits and costs of an AVM system. This will require discussions with command staff, data collection and certain elementary types of analysis. The city might benefit greatly from impartial assistance from the outside in performing such an analysis.

The first step in discussing the possibility of an AVM system with command staff is the listing of probable benefits of the system. Such a list might include the following:

- Reduced response time
- Increased officer safety
- Improved command and control operations
- Better dispatching techniques

- Improved management of resources in the field
- Improved crisis management ability and real-time direction of criminal pursuit
- Increased police patrol effectiveness using such indicators as more miles driven on preventive patrol and more self-initiated activities
- Improved morale due to a higher perceived level of professionalization
- Ability to recreate and to study situations in the field (via videotape playback or a similar medium)
- Improved public image

Next to such a list should be created a list of possible disadvantages of an AVM system, perhaps including:

- Increased cross-beat dispatching (thus bringing a loss of "beat identity")
- Possible increased dispatcher workload
- Possible negative response of patrolman's union (representing officers who might resent their position being monitored)
- Increased annual costs (due to operational and maintenance costs of the system and amortized purchase cost)
- Negative consequences stemming from possible abuse of the system

If, as a result of preliminary meetings, the possible advantages seem attractive (even given the possible disadvantages), then some more formal steps of analysis should be undertaken.

1. Review of Police Emergency Response System. The first formal step, which might require outside assistance, is a review of the police emergency response system and the collection of data

describing this system. First, a block diagram (similar to Figure 6-2, page 182 of the Phase I Final Report) depicting each of the key steps in the emergency response system would be generated. Then the parameters of the system would be defined. These would include both controllable parameters, such as the number of telephone complaint clerks (call evaluators), number of dispatchers, and number of radio-dispatchable patrol units (all by time of day) and uncontrollable parameters, such as rate of calls for service (by type and time of day); service times of complaint clerks, dispatchers, and patrol units; miscellaneous processing delays; response speeds; and the description of the patrol resource allocation policy. If a city is interested in reducing response time, AVM is only one of many potential changes that could be made.

The sample size for these data need not be huge, perhaps totalling a period of four weeks of operations (preferably one week from each season of the year). The data should be processed to compute summary statistics such as mean, median, mode and variance.

2. Use of Simulation Model or Comparable Tool. The next step is to review the police emergency response system with respect to possible improvements that could be instituted--both in terms of the extent of improvement and cost. In the area of reducing response time, the following are potential improvements:

- Institution of a 911 system
- Implementation of an ACD (Automatic Call Distribution) system

- Implementing a CAD (Computer-Aided Dispatching) system
- Rescheduling of complaint clerks
- Rescheduling of dispatchers
- Rescheduling of patrolmen
- Modification of the dispatching procedures (perhaps by priority of call)
- Implementing an AVM system with specified accuracy characteristics
- Addition of one or more radio channels

Many of these changes bear on the other entries in the list of benefits (in addition to response time reduction). Additional changes that are not directly related to response time include:

- Improved training of complaint clerks and dispatchers
- Enhanced public education in the use of the police emergency number
- Institution of specialty units in the field (e.g., for family crisis intervention, emergency medical services, etc.)

Many of these alternatives for improvement will have to be treated subjectively, that is, without recourse to detailed statistical or modeling analysis. Others require more formal treatment, such as predicting the response time savings accruing from an AVM system. This analysis can be carried out in a fairly inexpensive manner by using a patrol force simulation model, such as the one applied in Chapter VI, described in Chapter VIII and detailed in Appendix C of the Phase I Final Report. For instance, the simulation model, when applied to District 3 in

St. Louis, indicated that almost half of the predicted 25% reduction in mean travel time was due to the MPD's precinct-oriented dispatch policy; when compared to a more standard non-precinct-oriented policy, AVM was predicted by the simulation model to reduce mean travel time by 10 to 15%. The simulation used in this study is in the public domain and will be made available for the cost of reproduction and mailing.

While the analyses we are suggesting need not be as detailed as those described in this report, the point of the analysis is to lay out all the major alternatives for improving performance of the police emergency response system and to indicate that installation of an AVM system is just one of those alternatives. Its ranking competitively with other alternatives will depend on subjective and objective analyses of costs and benefits of the system in comparison to each of the other alternatives.

B. Critical Factors of Concern

Once the initial analyses have been performed, if AVM is then being seriously considered as a potential means for improving police services, then there are several key factors with which potential consumers should concern themselves. It is recommended that each of these factors--detailed below--be critically discussed and reviewed prior to signing any contract for an AVM system. For convenience, the factors can be grouped into the three categories underlying the St. Louis evaluation: operational, technological and attitudinal.

1. Operational Factors.

a. Accuracy. Any AVM system should have one or more meaningful measure(s) of accuracy. In the FLAIR System the three main measures were the mean time between losses of a FLAIR vehicle, the location error (in feet) representing 95% confidence,[25] and the mean error (in feet). AVM systems, other than dead-reckoning types, use only the location error measures to define accuracy since such vehicles do not become "lost." However, other systems may have their own unique measures; for instance, the manufacturer of a fixed post sensor system might quote the mean time between passings of a sensor.

Whatever the choice, the contract for delivery of the system should contain a clause guaranteeing a level of performance as indicated by the relevant measure(s) of accuracy; and the test procedure for verifying that performance should be agreed upon.

The level of accuracy required will be determined by the needs analysis discussed above. A very dense city with narrow streets, small blocks and limited long-range visibility will in all likelihood require a more accurate system than in a more "sparse" city. A city that selects an AVM system for command and control operations and officer safety as well as response time reduction will most likely require a more accurate system

[25] Vehicles are correctly located within that distance 95 percent of the time.

than one whose only purpose is travel time reduction (e.g., having a location error within 220 feet, 95% of the time).

The value of the accuracy parameters may also have a direct bearing on other components of the emergency response system. For instance, a FLAIR-type system with mean time between losses of a vehicle of six hours would require 2,000 dispatcher reinitializations per day in a fleet having 500 vehicles. If each reinitialization consumed 15 seconds of time, then the summed extra workload for this task would be 8 1/3 hours per day.[26] An increase of mean time between losses (per vehicle) to 12 hours would reduce this dispatcher workload to 4 1/6 hours; however, a system not having a binding value of this performance measure might yield an unsatisfactory mean time between losses of two hours per vehicle, which would result in an extra workload at the dispatchers' positions of 25 hours per day.

It is important that any police department contemplating an AVM system be aware of the various accuracy definitions of alternative AVM systems and the implications of each on its operations. Chapter II of the Phase I Final Report describes alternative AVM systems and accuracy considerations.

b. Need for Response Time Reduction. AVM systems are typically "justified" on the basis of their response time reduction

[26] Part I reported workload increase for dispatchers of over five minutes per hour (9%), but after the learning process was completed, time savings from other factors (such as digital communication) more than offset this time increase. The fact remains though that the fewer the reinitializations, the less workload for the dispatchers.

benefits. One purpose of the needs analysis discussed above was to determine representative values of response time for each of the components of the police emergency response system. Only then can one determine if the reduction in travel time (typically 10 to 15 percent) derived from an AVM system justifies the cost of the system; and one must remember that the AVM system might increase the response time of some other component of the system.

In addressing the issue of response time reduction, the potential consumer should consider the following:

- Little is known about the relationship between response time and apprehension probability.[27] Response time as a key performance measure is a surrogate measure, albeit not an unreasonable one.
- The potential average travel time reductions possible from an AVM system vary according to patrol workload (on calls for service and other matters). The average reduction typically starts at some positive value (say 10% improvement) at zero workload, builds to a maximum (say 15% improvement) at about 20 to 30 percent workload, and then gradually drops to 0% improvement as workload approaches 100%.[28]
- In addition to addressing the average travel time reduction of an AVM system, one should look at the distribution of travel time reductions. Typically, the majority of dispatch decisions are unaffected by AVM information. However, those dispatch decisions that are changed due to AVM may result in a travel time reduction of 25 percent, 50 percent, or more. Such distributional effects also vary by location within the city.
- In an urban environment, travel time, as a component of total system response time, rarely exceeds about 50 percent of total system response time. Thus, a 10 percent reduction in travel time is not likely to decrease total system response time by more than about 5 percent.

Even if total system response time is found to be unaffected by an AVM system, there may be other important reasons for implementing the system. These have been discussed elsewhere in this report.

c. Tie to CAD. The Science and Technology Task Force of the President's Crime Commission, when discussing AVM systems, viewed them primarily as a key component of a CAD (Computer-Aided Dispatch) system. In the late 1960's most police emergency response systems were founded on a technology that had not changed appreciably since the 1930's. CAD systems were technically feasible, building from recent developments in on-line computer time-sharing systems. And the capital investment in a CAD system, which would still be under $1,000,000 for most cities, almost always represents a smaller incremental investment than a high accuracy AVM system (implemented city-wide). Finally, certain call processing improvements can be accomplished solely with a CAD, without the assistance of automatic vehicle location.

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[27] The best two studies are by Isaacs in an Appendix to the Science and Technology Task Force Report of the President's Crime Commission (a study done in Los Angeles) and by Clawson and Chang in Seattle (to appear in a special issue of Management Science on Criminal Justice, A. Blumstein and R. Larson, co-guest editors.

[28] For a more comprehensive discussion, see Chapter VI, Section D-1, pages 204-209 of the Phase I Final Report.

Implementing an AVM system before a CAD system results in less than optimal performance of the AVM system. Such activities as manual cursor positioning for incident placement could be performed virtually instantly by a CAD computer, but they represent increased workload to a dispatcher in a manual system. Also, dispatching personnel trained in the ways of a computer within a CAD context are likely to be less resistant to the notion of AVM information, which would appear to them to be a natural add-on to the CAD system.

For these reasons, potential consumers of AVM systems should think carefully about the advisability of AVM without CAD and about the time phasing of CAD and AVM installation. It is not difficult to write into the specifications of a CAD system features that would make it compatible (with minimal switchover costs) with an AVM system. While it is conceivable to design AVM systems that "stand alone" and yet are likely to be compatible with some yet-to-be-designed CAD system, it is more difficult to do so and likely to be more costly to switch over. A CAD System "waiting for an AVM hookup" is likely to yield beneficial improvements in operations (as they have since 1968, when New York City's SPRINT system was installed), whereas an AVM system waiting a CAD connection is likely to yield less than the full advantage of AVM information.

d. <u>Need for More Knowledge of Patrol Activities</u>. Prior to the installation of an AVM system, serious attention has to be focused on the patrol force to discover just how its members

spend their time. A good illustration of a detailed analysis of patrol activities is contained in the technical write-up of the Kansas City Preventive Patrol Experiment[29], combining police "noncommitted time" and time spent on activities known to the dispatcher.

A main reason for such a study is to discover the fraction of time that a unit's position is mobile and therefore unknown to the dispatcher. The higher this fraction of time, the greater the benefits of an AVM system; the lower, the less benefits. Just as a fire chief would have limited use for an AVM system (since he is almost always aware of the location of his fire apparatus), a police chief suffering from an overabundance of calls for service would have limited use for an AVM system. This is because a system saturated with calls for service has the great majority of its units positioned at scenes of calls for service (i.e., known locations); and, most dispatches occur in a back-to-back manner from a queue of waiting calls, assigning a unit at a known location to an incident at a known location. In such a system, the need for AVM information would be minimal; most likely, other changes should occur first in the police emergency response system (perhaps an increase of manpower in the field or a stricter call screening policy).

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[29] "The Kansas City Preventive Patrol Experiment: A Technical Report," by George L. Kelling, Tony Pate, Duane Dieckman, and Charles E. Brown, published by the Police Foundation, Washington, D.C., 1974 (537 pp. plus appendices). Also see their "Summary Report" (60 pp.).

A patrol force with adequate manning to handle its call-for-service volume is more likely to incur benefits from an AVM system. But even in these cases the exact magnitude of the benefits may be surprisingly city-dependent. For instance, the Kansas City Report indicated that fully one-half of police noncommitted time was at stationary locations rather than mobile locations. This could mean an availability to the dispatcher significantly smaller than that suggested by call-for-service workload, or it could suggest that one could know the exact location of about one-half the noncommitted fleet without an AVM system, simply by instituting a call-in procedure whenever a unit stops at a fixed location.[30]

Following the recommended "before" component of patrol time analysis, one should continue the analysis after the implementation of AVM. In addition to all the "before" questions, one can now examine patterns of patrol (as to which is more effective against certain types of crime), space-time dependence of crime (say armed robbery) and patrol units, etc.

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[30] As part of the Phase I St. Louis evaluation, an attempt was made to include in the analysis police committed time not associated with calls for service. This was done by generating "patrol-initiated activities" in the simulation model of District 3. Even with this capability, however, predicted travel time reductions were greater than those measured, perhaps indicating additional committed time not incorporated in the model. Since the amount of committed time has such a direct bearing on the utility of an AVM system, it will be a focus of the Phase II evaluation.

2. Technological Factors.

a. Maintenance and Technological Obsolescence. AVM systems are based on the latest state-of-the-art technology, usually employing digital communications, solid state circuits, and computationally fast minicomputers. None of these systems has experienced a multi-year test in the operationally severe environment of a police department. Thus, as was evident in our Phase I evaluation, it is likely that maintenance problems will arise that were unanticipated prior to implementation. Even if they don't, the type of anticipated maintenance--on digital communications equipment, on small solid state circuits, on minicomputers--represents a major advance in technological sophistication of the maintenance personnel of most police departments.

Both scheduled and unscheduled maintenance on these systems will undoubtedly be required and a police department contemplating the purchase of a system employing such technology should carefully plan out their maintenance policy ahead of time. It is likely that some maintenance tasks will have to be subcontracted to outside specialist firms--say for the minicomputer. Other tasks may be assumed by the department's regular maintenance personnel, provided adequate plans are laid out for their training, the upgrading of their test and repair equipment, and backup services should they run into difficulty.

An estimate of the annual cost of maintenance should be included in the early deliberations, prior to a department committing itself to a particular system. Costs of maintenance contracts for minicomputers can be significant. Typically this cost is 1% per month of the original purchase price. For a redundant system (with two computers) and with peripheral equipment valued at $200,000, the annual cost would be $24,000. Costs of upgraded in-house maintenance can also be high, considering the associated new equipment, space and perhaps additional personnel. A department contemplating an AVM system might consider including the cost of maintenance equipment, training, and perhaps even all first-year maintenance as part of the purchase contract.

Because of the state-of-the-art technology used in AVM systems, the technology is changing rapidly on a year-to-year basis. New system concepts are known to be under development (e.g., passive signpost systems) and systems now undergoing trial implementation in major cities (e.g., FLAIR in St. Louis, Hazeltine's pulse trilateration in Dallas, and Hoffman's Proximity Sensing in Huntington Beach) are likely to involve further refinement. This means that 1) installed systems are likely to become technologically obsolete perhaps as soon as five years and almost certainly within ten years, and 2) the passage of time is likely to result in less expensive systems. Thus a department contemplating the purchase of an AVM system is confronted with an "action-timing" problem--namely, when to purchase, considering factors such as price, technological

obsolescene, tests in operating police departments, etc. Evaluation results of currently implemented AVM systems--such as those in St. Louis, Dallas and Huntington Beach--plus AVM consumer "handbooks"[31] should help a department confronting such a decision.

b. <u>Accountability of Hardware Vendor</u>. The supplier of the AVM system should be required to deliver a system which performs according to prestated specifications. These should be spelled out in detail in the contract. These specifications could be stated in terms of target levels for the key performance measures of the system.

As an illustration, a set of system performance measures (for a computer-tracked dead-reckoning system) may look something like this:[32]

(1) <u>Accuracy</u>

- Mean time between losses of a vehicle driving routinely should be no less than six hours.
- Mean location estimation error of a properly tracked vehicle should not exceed 75 feet.

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[31] For instance, see G.R. Hansen and W.G. LeFlang, "Application of Automatic Vehicle Location in Law Enforcement--An Introductory Planning Guide," Jet Propulsion Laboratory Doc. #JPL 5040-17, Pasadena, Cal. 91103, 1976.

[32] The numerical values used here are <u>illustrative</u> and are not meant to imply a recommended set of standards for every city.

- There should be no driveable places within the city at which the system does not function.

- The system should be able to track in "open loop" mode (off mapped streets) for five minutes, accumulating an error of no more than 200 feet 95% of the time (assuming speeds and turns usually associated with a patrolling vehicle).

(2) Maintenance and Repair.

- Mean time between failures of in-car AVM equipment should exceed 60 days (per car).

- Mean time to repair the in-car AVM equipment should be less than three man-hours.

- Mean time between failures of the primary tracking minicomputer should exceed 60 days.

- Percent of time system totally operational shall exceed 99.8 percent.

(3) System Capacity.

- The system will be capable of tracking 400 vehicles under normal operating procedures, using two-UHF "voice" channels.

- The system will be capable of tracking 400 vehicles, with up to 100 executing a turn in the same polling interval.

(4) System Adaptability.

- The system manual will provide a detailed description of how to link up the software to a compatible CAD system (with pre-specified file formats, for instance geographical files).

- The system manual will spell out in detail how likely changes in the city's street layout are to be incorporated into the system.

The above performance measures, target values, and related specifications were illustrative only. An actual contract might contain more (or fewer) specifications and, undoubtedly, their numerical values would be different and city-specific. However, without such a list of specifications the consumer has no assurance of "what he is getting." The time necessary to detail these requirements is minimal in comparison to the time (and cost) involved should the system not perform according to the consumer's expectations.

c. Costs. Certainly cost is a major consideration when contemplating an AVM system. It appears that the cost estimates of the Science and Technology Task Force of the President's Crime Commission, which were in the range of $500 to $1,000 per vehicle, were quite optimistic for a high accuracy vehicle monitoring system. While exact cost estimates are difficult to quote due to the lack of production line quantities, it appears that the cost per car of the FLAIR System (including apportioned costs of the central facility--with computer and displays) exceeds $7,000 (and we have used $9,500 as a planning figure). Few systems appear to be available that would cost less than, say, $2,500 per vehicle, and the less expensive systems tend to offer less accuracy and fewer features than the FLAIR System.

While these purchase costs may appear high, one must consider, on the other hand, that city police departments are typically labor intensive and under capitalized. As discussed in Part I, it is not unusual for 90 percent or more of a police budget to be consumed directly by salaries, fringe benefits, and pensions. The annual cost of a round-the-clock two-person patrol unit now ranges between $200,000 and $350,000 in most cities, the latter high figure deriving from ever-more-generous pension plans. So, the apparently high purchase costs of an AVM system are likely to be small in comparison with personnel costs.

In addition to purchase costs, which can be amortized over the likely lifetime of the system, there are yearly operating costs. These are due primarily to maintenance and repair, any special staff that has to be hired, space (occupied by the system), electrical power (consumed by the system), and the percent of time of regular personnel devoted to the operation of the system. These costs may be offset by cost savings due to a reduction inthe regular patrol force made possible by increased efficiency and effectiveness of the force due to the AVM system. There may also be non-cost benefits resulting from improved officer safety and more effective command and control, the value of which must be considered in the final decision.

Any city contemplating an AVM system should as accurately as possible lay out the main components of costs, both one-time and recurring. In doing this, the one-time costs should be amortized over the lifetime of the system, which for planning purposes, will probably be about ten years.

3. Attitudinal Factors.

a. Morale, Attitudes, Education. Given a system that is technologically sound, in projecting the degree of implementation success, it is difficult to identify a concern more important than the attitude of police personnel toward the AVM system. A highly positive attitude would greatly increase the chances that the system will function for the purposes intended. A highly negative attitude will almost certainly result in the effective failure of the system. Virtually all systems are subvertible in some way and a negative attitude could lead to acts effectively terminating useful system operation. Strong negative attitudes could also yield a tough union bargaining position at the next round of contract negotiations.

There appear to be two key ingredients in influencing positive police attitudes toward an AVM system. The first is the requirement of a properly working system. Police have little tolerance with an obviously faulty system that is being marketed to them as a potential life saver. Like many members of the general population, many police officers recall past events by their deviation from the norm, not their adherence to it. Thus, obvious failures of an AVM system (during the early implementation phase)--even if only a few in number--could be sufficient to turn an originally positive attitude into a largely negative one. Especially if they start to question the reliability of the system during a potential life or death situation, confidence will be eroded and attitudes will turn downward. To the extent possible, an implemented system should be thoroughly tested under realistic field conditions prior to transferral of the system to police personnel. This may require installation within the city and simulated police driving for an amount of time prior to transferral.

The second key ingredient is education and communication regarding the new system. Patrol officers, dispatchers and supervisors must be thoroughly briefed on the purposes of the system. This includes officer safety, assisting in criminal pursuits, reduced response time, and all the other objectives cited earlier. The issue of position monitoring by supervisors should be openly discussed and the department's policies in this area presented candidly. The step-by-step detailed operation of the system should be presented, along with possible operational problems or limitations. A lack of comprehensive educational programs and communication on such topics could result first in confusion and misuse of the equipment and second in frustration and increasing skepticism regarding the utility of the system.

b. Subvertibility of the System. By system subvertability, we mean the susceptibility of the system to deliberate acts aimed at decreasing system effectiveness. In computer-tracked dead-reckoning systems, for example, such acts could be performed by the patrol officer--reporting an incorrect address at the time of "loss correction" (or reinitialization) or self initializing at an incorrect site--or they may be the work of vandals or criminals deliberately planning to make the AVM system inoperative.

While well-trained and highly motivated patrolmen are not likely to engage deliberately in acts aimed at foiling the system, virtually any patrol force contains a spectrum of officers, each with different attitudes toward technological innovations such as AVM systems. A dispatcher-triggered alarm system that was implemented several years ago in Boston was quickly destroyed when the in-car units became inexplicably inoperable. A completely voluntary vehicle location system implemented on a trial basis in Oakland, California failed due to technical problems and, in part, its voluntary position reporting feature.[33] We are led to believe that system subvertability is tied directly to the extent of "voluntariness" of the system--the less frequently the officers must report or correct their location, the more technically successful the system is likely to be.

With FLAIR-type systems, even if mean time between failures for a fleet is shown to be, say, eight hours, this value pertains to average (typical) driving patterns of a patrolling vehicle. As long as there are parts of the city in which the system does not function (e.g., due to magnetic anomalies), then subvertability and "voluntariness" are increased. However, vehicles that frequently try to become "lost" can be spotted on computer printouts,

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[33] Scott Hebert, "Communications and Dispatching Technology in the Oakland Police Department," Chapter 7 of a Final Report to be submitted to the National Science Foundation on the Innovative Resources Planning Project carried out at MIT and sponsored by NSF-RANN (National Science Foundation Grant Number G038004).

and if investigation indicates no faultiness in the vehicle's hardware, appropriate discussions can be held with the officers involved.

The second type of subvertability is due to work of vandals or serious criminals. Regarding vandals, one must question the security of systems having spatially distributed components (such as proximity sensing systems). How secure are callboxes at intersections or magnets or coils in the roadway? How secure are transmitters? These questions are far from academic since several cities have recently experienced severe tampering with their police callbox systems.

The serious criminal poses perhaps the greatest problem with regard to system subvertability. In any AVM system one must raise the issue of jamming of the frequency (or frequencies) used between mobile and base station. At present there does not appear to be a reasonably inexpensive way to counter such a tactic; as a minimum precaution, the identities of these frequencies should not be publicized. Any in-field hardware that is susceptible to vandalism is also a target for the serious criminal. While it is impossible to design a foolproof system, these issues should be kept in mind when considering alternative systems to install.

c. <u>Response of Patrolman's Union</u>. In many cities in the U.S. within the last 10 to 20 years, the unions or fraternal organizations (<u>de facto</u> unions) representing patrolmen in labor matters have gained considerable power. Their influence has

extended beyond such standard labor negotiation issues as wages, pensions, dues check off, and rules on overtime, and into certain operational management areas previously thought to be management prerogative. These include work rules (scheduling of tours of duty, assignment to precincts, assignment to special details, one-person versus two-person cars) and methods of operation (e.g., response of two vehicles to certain types of incidents).

With proper attention given to the patrolman's perspective, it is possible that the union could be an integrative force in explaining the benefits (to the patrolman) of an AVM system. From his perspective, the likely benefits are officer safety, assistance in criminal pursuits, increased coordination in crisis situations, and improved morale due to a higher perceived level of professionalization. Travel time reduction may play a positive role here too, although many patrolmen think that nearby officers will "volunteer" for high-priority calls, thereby reducing the projected travel time reduction benefits of an AVM system.

As illustrated in our St. Louis officer surveys, the major initial concern of patrolmen regarding AVM systems was the unwarranted monitoring of their positions by supervisors (or worse yet, bureaus of "internal affairs") and the possible reprimands that may result. They argue, correctly in many instances, that one cannot determine the activity of a patrol officer by merely monitoring his position. A vehicle stopped for two hours may be performing an important stakeout function. On the other hand, the officer may be taking an unauthorized rest break. AVM systems are likely to reduce fraternizing among patrolmen in the field--a habit that many patrolmen will argue serves a necessary communication function (including exchange of crime-related information). In District 3 in St. Louis there are indications that fraternizing within the station house increased markedly after implementation of FLAIR.

There are other activities, too, both good and bad, that will tend to be curtailed as a result of AVM. The patrolmen's union can be relied upon to represent the patrolman's interests in these matters. In a city in which police labor and management continually clash, AVM may be virtually infeasible due to union hostility. In a city with "collusive"[34] bargaining relations between labor and management, it is likely that compromise understandings can be reached. In a city having traditionally good labor-management relations, implementation of AVM should be no problem, provided again that the patrolman's perspective is considered.

We cannot overemphasize the need to consider "labor's" response to such technological innovations as AVM systems. An otherwise excellent system can be made unworkable by failure in the labor-management area.

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[34] Margaret Levi, Conflict and Collusion: Police Collective Bargaining, IRP Technical Report No. TR-07-74, September, 1974 (237 pp.), Innovative Resource Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts.

C. Long-Term Commitment to AVM

Installation of an AVM system in police operations could be, in many ways, parallel to the installation of automobiles (to motorize patrolmen in the 1910's) and the two-way radio (to enhance communication capabilities in the 1930's). Thus, a switch to AVM (like CAD, advanced 911, and several other new high technology systems) is not likely to represent a temporary mode of operation, but rather one that can and will affect in a permanent way the very essence of policing in any department that employs it. So, cost and other more immediate considerations aside, the long-term consequences of an AVM system should be discussed and projected by departmental personnel. Recurring cost and personnel obligations in order to keep the system functioning and up-to-date should be outlined, and financial commitments from the city should be obtained, if needed.

With our current state of relative ignorance with respect to the actual in-the-field effects of an AVM system, it may be several years (requiring monitoring and evaluation of the first several AVM installations--such as that in St. Louis as well as experience in Dallas, etc.) before a department can, with some confidence, project the effect of an AVM system on its own operation. Thus, in learning to project the long-term consequences of an AVM system, it is essential that we follow the scientific method to the extent possible, thereby allowing learning from the early implementations through the process of observation, hypothesis generation, and testing with careful attention to operational, technological and attitudinal concerns.

END

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