EVALUATION OF THE BENEFITS OF A REAL-TIME INCIDENT RESPONSE SYSTEM

Andrey A. Petrov,
Pei-Wei Lin,
Nan Zou,
Gang-Len Chang
pwlin@wam.umd.edu

Phone: (301) 405-6550
Fax: (301) 405-2585
1173 G. Martin Hall,
Dept. of CEE,
University of Maryland
at College Park,
20740, MD, USA

Jean Yves Point-Du-Jour
Maryland State Highway Administration
jpoint-du-jour@sha.state.md.us

The need to implement an effective Incident Management Systems (IMS) has received increasing attention from general public, media and policy makers, that in turn has required transportation agencies to perform a rigorous evaluation over any implemented plan. Since 1996, the Maryland State Highway Administration (MSHA) has conducted a comprehensive evaluation of its incident response and management program, named CHART. The evaluation consists of analysis of incident characteristics, evaluation of system efficiency and effectiveness, and estimation of benefits to the users. This paper is focused on presenting the results for the year 2000 CHART evaluation.

INTRODUCTION

CHART (Coordinated Highways Action Response Team) is the highway incident management program of the Maryland State Highway Administration (MSHA). Initiated in the mid 80' as "Reach the Beach", it has been extended to a statewide program headquartered in Hanover, Maryland where the Statewide Operations Center (SOC) is located. The SOC is also supported by three satellite traffic operations centers (TOC), where TOC-3 is based in Washington D.C. region, TOC-4 in Baltimore, MD, and TOC-5 being seasonal. The current network as shown in Figure 1 covered by CHART consists of both statewide freeways and major arterials with a total length of about 450 miles (~700 km).

Figure 1. Area Road Network Map Covered by CHART

As most delays experienced by highway drivers are due to incidents, the focus of the evaluation is to assess the effectiveness and efficiency of the CHART program, especially with respect to its ability to detect, response and manage non-recurrent congestion on the principal highway network. The entire evaluation report includes three parts: analysis of incident characteristics, operational efficiency and benefits to the users as well as the entire environment. The analysis of incident characteristics consists of the following classifications:

- By road and location
- By lane blockage and operational duration
- By peak and off-peak hours
- By weekdays and weekends

The system efficiency evaluation covers the following five parameters:

- Detection sources
- Response time
- Operational duration
- Response rate for detected incidents
- Reduction in the duration of incident operational periods

Estimation of benefits includes computation of reduction in vehicle delays, potential reduction of secondary incidents, reduction in vehicle emissions and roadside assistance to drivers.

DATA AVAILABLE FOR ANALYSIS

Table 1 summarizes the data collected by CHART during year 2000 in comparison with the same categories of data from the year 1999 incident record. Within this table, Long Forms are used to record major accidents, and minor incidents, reported in Short Forms, are divided into two sub-types with code 1046 standing for assistance to drivers and 1050 for incidents. However, there were some reports without indicating the incident type, but contained other information. Those reports were classified into the group named "Unknown". The year 2000 data differs from these in year 1999 by about 7000 more reports from TOC-4, and has an increase in the number of minor incidents compared to the previous year. A total of 16,000 MSP (Maryland State Police) reports were analyzed for computing secondary incidents.

Table 1. Data collected for analysis from 1999 and 2000

Division	Report Type	2000	1999	Inc. Type	2000	1999*
SOC	Long Forms (12 months)	786	909			
TOC-5	Long Forms	0	0			
	Short Forms (April-October)	1,290	0	*1046*	1,041	0
				1050	128	0
				Unknown	121	0
TOC-4	Long Forms	500	223			
	Short Forms	13,771	6,171	*1046*	8,874	5,105
				1050	2,042	415
				Unknown	2,855	561
TOC-3	Long Forms	1,165	1,134			
	Short Forms (12 months)	17,379	19,550	*1046*	10,513	17,049
				1050	4,066	2,319
				Unknown	2,800	182
Total Collected Data		34,891	27,987			

ANALYSIS OF INCIDENT CHARACTERISTICS

Methodology developed for CHART evaluation at this stage allows the project team to make the analysis based on the data with the highest quality. To extract all possible data that contains necessary parameters. Evaluation process followed the procedures described in the introduction and began with analysis of incident distribution by road and location as shown in Figure 2.

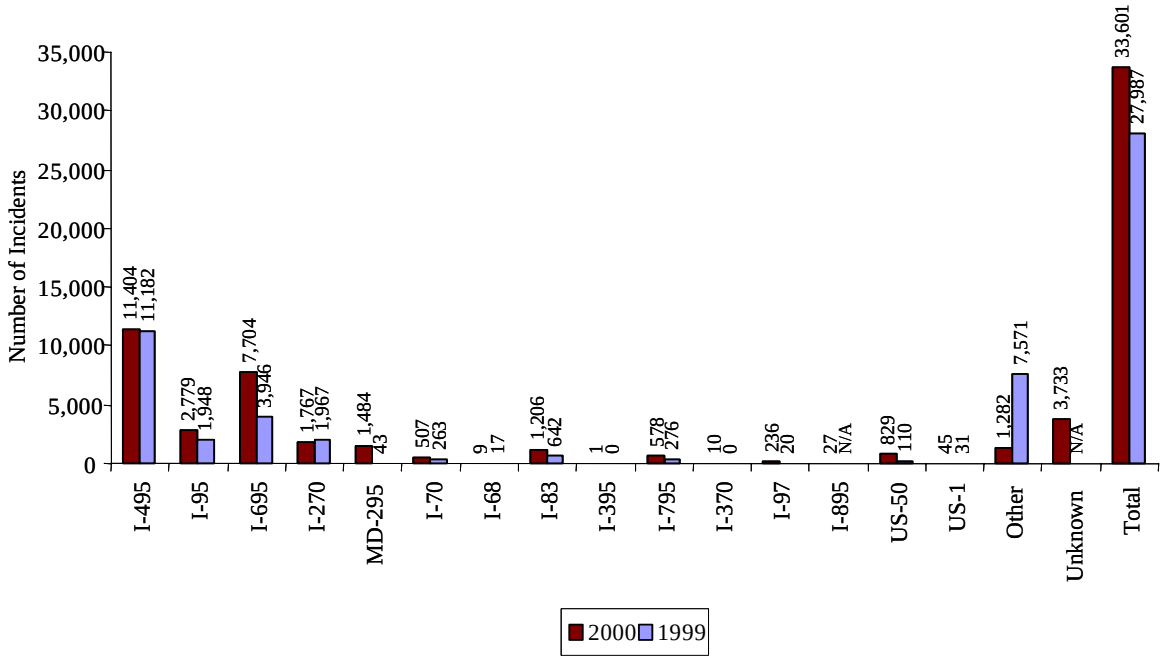

Figure 2. Distribution of Incidents along the Roads of the Network

Overall, the distribution of incidents along the roads supported by CHART is organized into three groups of corridors. The first group includes I-495, I-695, I-95 (excluding part of I-495/95) and I-270, which have 11,404; 7,704; 2,779 and 1,767 incidents year 2000, respectively. Incident frequencies for this group show that for each of these corridors, CHART has responded to an average of 33, 21, 8, 5 incidents per day. The second group consists of I-70, I-83, I-795, US-50 and MD-295 and the third group includes all other roads covered by CHART. Out of the total 33,600 incidents, there were 2,451 severe incidents reported to cause lane blockages. The distribution of those incidents is presented in Table 2.

Table 2. Distribution of incidents by lane blockage

No. of Major Incidents	No. of Minor Incidents, Assistance to Drivers
• Shoulder - 424	• Shoulder - 26,946
• 1 Lane - 518	• 1 Lane - 2,677
• 2 Lanes - 895	• 2 Lanes - 1,274
• 3 Lanes - 342	• 3 Lanes - 136
• >=4 Lanes - 272	• >=4 Lanes - 75

Figure 3 illustrates the incident distribution by road, lane blockage and their durations for the Washington D.C. region during year 2000, where the numbers in each parenthesis shows the percentage of data available and reliable for analysis.

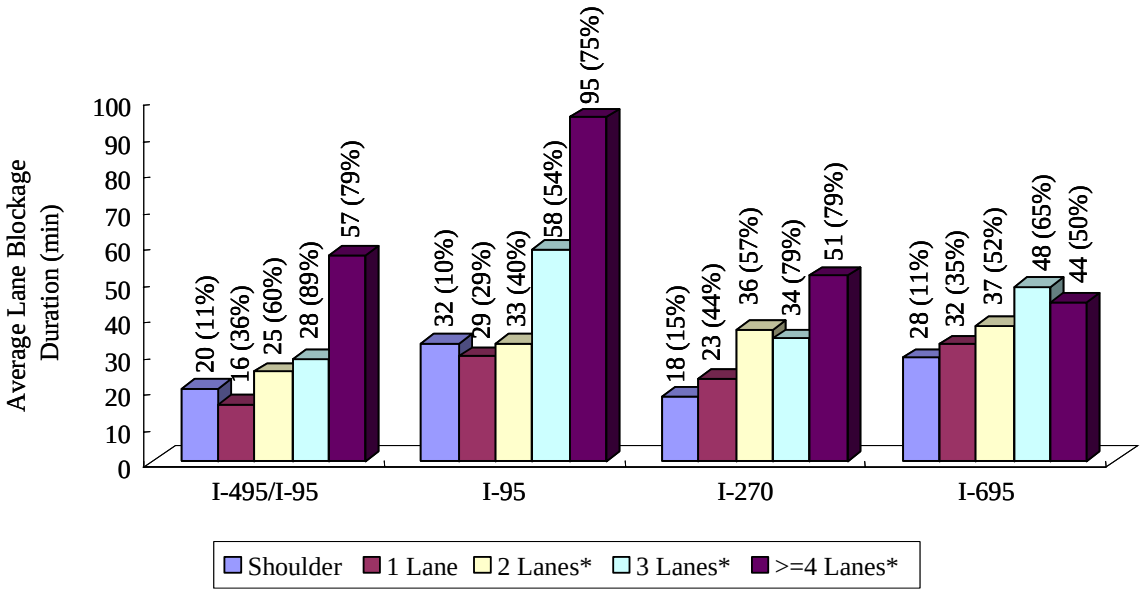

Figure 3. Lane blockages and their durations by road

It should be mentioned that most incidents did not cause over one hour of lane blockages. About 96.4 % of incidents managed by TOC-3 were cleared within 1 hour, and TOC-4 manage to clear 94.2% of incidents in less than one-hour period. The total number of incidents with duration between 1 to 2 hours responded by TOC-3 was 290, and 268 by TOC4. In addition to those accidents, there were 149 (by TOC-3) and 123 (by TOC-4) traffic blockages, which plagued the traffic for more than 2 hours. The distribution of all incidents by duration is summarized in the Table 3.

Table 3. Distribution of Incidents by Duration

Duration (Hr)	TOC 3		TOC 4		SOC		Total	
	2000	1999	2000	1999	2000	1999	2000	1999
< 0.5	1,194	4,865	5,782	3,346	81	96	7,057	8,307
>= 0.5 & < 1	1,087	462	891	213	160	141	2,138	816
>=1 & < 2	290	159	268	54	185	205	743	418
>= 2	149	76	123	36	246	264	518	376
Total	2,720	5,562	7,064	3,649	672	706	10,456	9,917

Among the reported incidents, 98% occurred during weekdays and 40% of these happened within peak hours defined as between 7:00 a.m. and 9:30 a.m., and 4:00 p.m. to 6:30 p.m. Those incidents are one of the main factors that cause congestions and delays, especially for the Capital Beltway and Washington D.C. Metropolitan area.

INCIDENT RESPONSE AND DURATION

Evaluating the efficiency of an Incident Management System (IMS) should be based on a number of key parameters, especially the time of detection, response, and recovery of traffic conditions (see Figure 4). Due to the lack of a sufficiently comprehensive real-time surveillance system, the data on incident detection, arrival of assistance vehicles to the scene, and the complete recovery time are not yet fully available under the current CHART operations. The closest parameter related to incident detection is the response time from detection to the arrival of response vehicles.

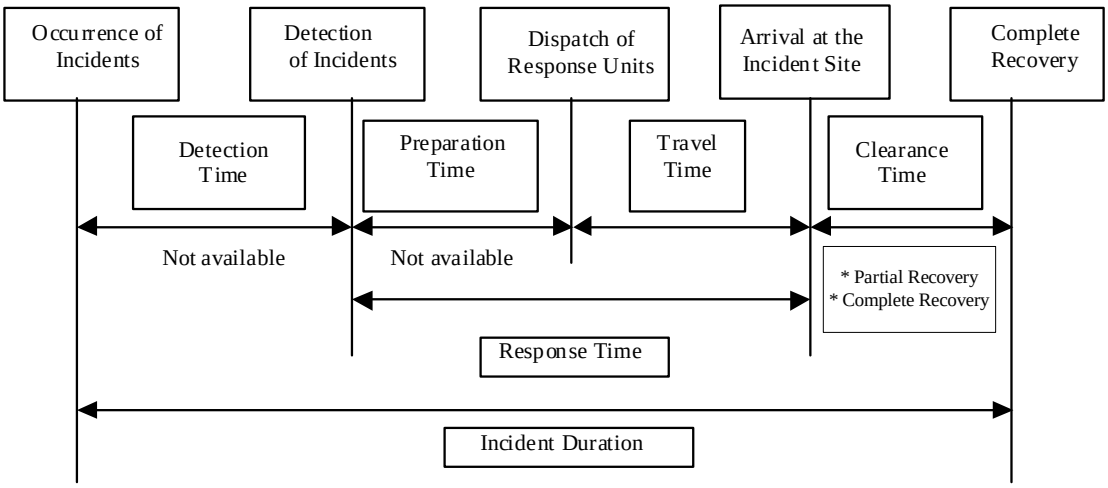

Figure 4. A Graphical Illustration of Technical Terms Associated with an Incident Operation *(Source: Performance Evaluation of CHART. Final Report 1997)*

Each parameter in Figure 4 was computed for each CHART operation centers and for the entire IMS. The average response time was founded to be 14.96; 15.43; 19.14 and 15.22 minutes for TOC-3, TOC-4, SOC, and the average of CHART as shown in Figure 5.

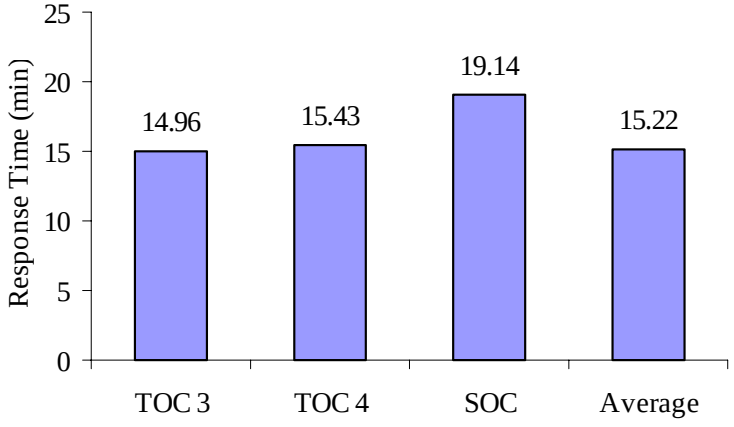

Figure 5. Response Time

To assess the contribution of CHART operations in terms of reduction in incident clearance time, this study has computed the average incident duration with and without the response of CHART, and the results are presented in Table 4. For the type of most frequent accidents, 2-lane blockages, it took an average of 35.53 minutes for CHART to clear the entire operation, and 79.67 minutes if CHART for some reasons was not able to do so. The averaging incident duration over all types of lane blockages is about 33 minutes with CHART operations and 77 minutes without it.

Table 4. Comparison of Incident Duration under Various Types of Lane blockage

Blockage	With SHA Patrol		Without SHA Patrol	
	Duration (min)	Frequency	Duration (min)	Frequency
1 lane	20.17 (29)	1,087	45.66 (56)	29
2 lanes	35.53 (52)	1,147	79.67 (85)	51
3 lanes	39.46 (54)	331	92.93 (109)	28
>= 4 lanes	69.60 (67)	245	102.36 (148)	14
Weighted Average	33.02 (42)		77.23 (93)	
Total Samples		2,810		122

(* The number in each parenthesis is the record in year 1999)

In comparison to the previous year, it is clear that all the emergency response agencies have improved their response times and at-scene operations. Overall, the effective operations of CHART has resulted in a 57 percent reduction on the average incident duration which, similar to its contribution in year 1999, has translated into a significant amount of driver and environmental cost savings.

RESULTING BENEFITS

Resulting Benefits due to CHART operations were divided into two major groups where the main one was: Direct Benefits to the Road Users, including:

- Assistance to Drivers
- Safety Benefits
- Reduction in Delay Time
- Reduction in Fuel Consumption

The second group of benefits was related to environmental benefits with respect to the Reduction in Emissions. Each of these benefits is presented briefly below.

ASSISTANCE TO DRIVERS

During the year 2000, CHART units responded to a total of 2,810 lane-blockage types of incidents and managed about 32,000 driver assistances that might influence traffic conditions on the network and result into further congestion and delays. Among all those driver assistance activities, 4,200 were to vehicles that run out of gas and flat tire as shown in Figure 6. This type of benefits may reflect in drivers' impression of State Highway Administration's performance and work quality, but is difficult to be quantified.

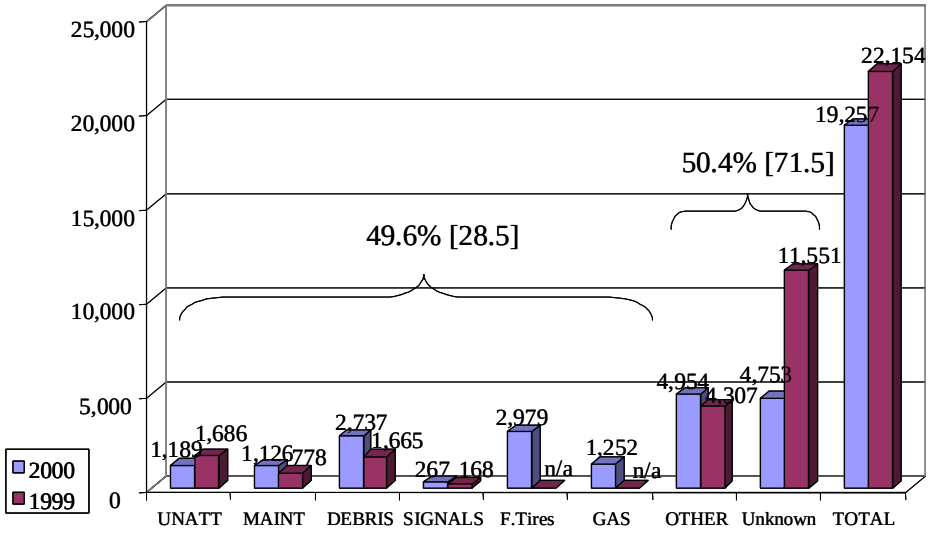

Figure 6. Assistance to Drivers

SAFETY BENEFITS

With respect to the improvement in safety, the potential reduction in secondary accidents was computed to be 1,267 incidents based on the Maryland police accident reports.

DELAY SAVINGS AND SAVINGS IN FUEL CONSUMPTION

To approximate the reduction in delay due to efficient incident response operations, freeways covered by CHART were divided into homogenous segments based on geometry and peak-hour volumes and the following models, obtained and calibrated in CHART 1997 Evaluation Study, has been used to perform the estimation of total reduction in delay and fuel consumption.

$$\Delta Delay = e^{-10.19} \times (Traffic\ Volume)^{2.8} \times \left(\frac{No.\ of\ Lane\ Blocked}{Total\ No.\ of\ Lanes}\right)^{1.4} \times (Incident\ Duration)^{1.78}$$

$$\Delta Fuel = e^{-10.77} \times (Traffic\ Volume)^{2.27} \times \left(\frac{No.\ of\ Lane\ Blocked}{Total\ No.\ of\ Lanes}\right)^{0.9} \times (Incident\ Duration)^{1.69}$$

The estimated results with respect delay reduction is shown in Figure 7, where all incidents in the year 2000 would cause a total of 66.59 millions vehicle hours if without CHART, substantially higher than the results with operations of CHART which is about 42.35 million vehicle hours. Thus, CHART's operations have contributed to a reduction of 24.24 million vehicle hours, slightly higher than the 23.36 million vehicle hours in year 1999. For convenience of comparison, cost of each hour of delay was set to be equal to $ 14.34 per hour, based on the average hourly income in Maryland 1997 when the evaluation of CHART performance was first initiated (6). The dollar value of reduced delays was computed as $347.6 millions, compared to 334.9 millions in year 1999.

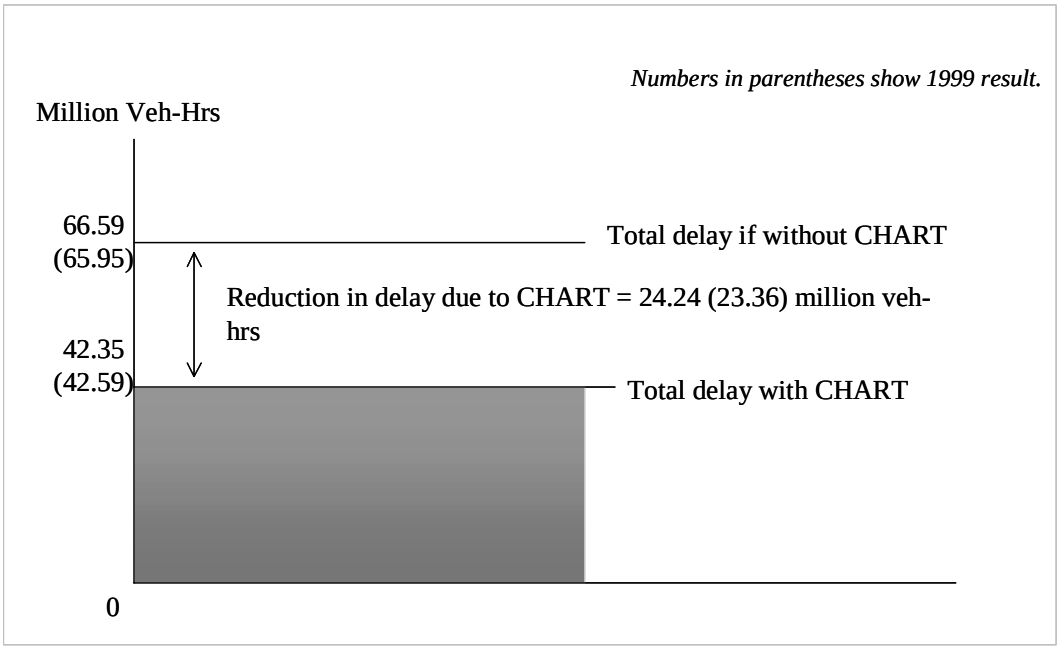

Figure 7. Delay reduction due to CHART

The fuel consumption was reduced in 2000 by approximately 4.1 million gallons. At a unit rate of $1/gal employed in year 1997, the total reduction in fuel consumption was about 4 million dollars. Note that due to the concern of data quality, the benefits associated with efficient removals of shoulder-lane incidents and assistance to drivers, which may otherwise incur significant rubbernecking effects during peak hours, are not included in this study. Also cannot be evaluated at this stage is the potential reduction in accidents due to efficient removals of stationary vehicles or large debris on travel lanes as vehicles under such conditions are forced to perform mandatory lane changes that are likely to result in some crashes.

ENVIRONMENTAL BENEFITS

Environmental benefits shall include noise reduction and air quality improvements. As it was mentioned in the methodology part, this project evaluates only air quality part of benefits from IMS operations.

Emissions Reduction

Parameters of vehicle emissions and costs per unit were obtained in year 1999 from the MDOT, and were quantified as follows:

- HC – 13.073 g/hour with a cost of $6,700 per ton
- CO – 146.831 g/hour with a cost of $6,360 per ton
- NO – 6.261 g/hour with a cost of $12,875 per ton

Using the total reduction in delays as the basis, the total benefits from emission reduction due to the CHART operations were computed as **26.7** million dollars or 2.1, 22.6, and 2.0 million dollars for each type of emissions respectively. The corresponding values of emission reduction benefits for year 1999 were 25.7 million dollars or 2.04, 21.81, 1.88 million dollars with respect to each type of pollutants. Finally, the total annual benefits for the Road Users and Community as a result of CHART operations on the principal road network of Maryland were computed to be **380** million dollars for the year 2000.

CONCLUSIONS

This study presents the approximate benefit of the incident management program, CHART, operated by Maryland State Highway Administration. Although some of the parameters, such as the time value of delay, may vary with the sources of data available for analysis, it is clear that the entire society can benefit significantly from an efficient and effective incident management program. This study has also evidenced that more resources should be allocated to incident response and management systems if we intend to effectively contend with ever-increasing congestion in the daily commuting traffic network.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Thomas Hicks, Mr. Michael Zezeski, and Mr. Eric Tabacek for their constant encouragements and numerous constructive comments during the entire research period of this project. This study cannot be completed without their strong supports. We are certainly indebted to SHA senior managers who offered

many suggestions regarding the report organization and presentation in a CHART monthly board meeting. We also like to extend our appreciation to the SHA Administrator, Mr. Parker P. Williams, Mr. Howard Simons from MDOT, and technical staff in both the CHART program and the Office of Traffic and Safety, especially the operators of the Statewide Operations Center and the two other satellite Traffic Operations Centers, who was involved in collecting and organizing the entire 2000 incident response data for this study.

REFERENCES

1. Meyer, M., "A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility", ITE, 1996.
2. Chang, G.L., Shrestha D., & Point-Du-Jour, "Performance Evaluation of CHART in 1997", University of Maryland at College Park, May 2000.
3. Chang G.L., Chang, I., & Point-Du-Jour, "Performance Evaluation of CHART in 1999", University of Maryland at College Park, July 2001.
4. Gillen, D., Li, J., Dahlgren, J., & Chang, E., "Assessing the Benefits and Costs of ITS Projects: Volume 1. Methodology." California PATH. University of California, Institute of Transportation Studies. Berkley, CA., March, 1999.
5. Meyer, M., & Miller, E., "Urban Transportation Planning: A Decision Oriented Approach" 2nd edition, International Edition 2001, McGraw-Hill, 2001.
6. Maryland Wages by Occupation, Maryland Department of Business and Economic Development.
7. "Evaluating Safety and Health Impacts, TDM Impacts on Road Safety, Personal Security and Public Health", TDM Encyclopedia, http://www.vtpi.org/tdm/tdm58.htm
8. Fenno, D., W., & Ogden, M., A., "Freeway Service Patrols, A State of the Practice", Transportation Research Record 1634, 1998.
9. Incident reports for 2000 from Statewide Operation Center, Traffic Operation Center 3 and 4, State Highway Administration, Maryland.
10. Maryland State Police Accident Reports in 2000.